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Brain Jelly – An Organic, Brain-Like Computer without Circuits or Logic Gates

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information

The human brain is the most powerful computer the world has ever seen. With its 86 billion neurons [1], less than originally thought (~100 billion, a myth of unknown origin [2]), the human brain is still at the top of the list and capable of remarkable feats, not only as far as computing power is concerned, but it is capable of self-programming, reasoning, data storage, and affords intelligence; at least in most cases. By comparison, digital computers are dumb slaves that do the bidding of their masters, the programmers, and rely on fixed nuts and bolts for their functioning. Furthermore, even the fastest computer currently in service, the Chinese NUDT Tianhe-2 with a capacity of 33.86 petaFLOPS (10^{15} FLoating-point Operations Per Second) [3], is only capable of handling one problem at a time and sequentially one bit at a time. The human brain's computing is significantly slower, but more flexible and dynamic in that neurons handle complex problems in a massively parallel way and during this processing, new neuron connections are formed to optimize the solving performance. The net result is an unparalleled capacity to solve highly complex tasks simultaneously, such as coming up with string theory (or more likely tonight's grocery list), whilst riding a bicycle home from University through rush hour traffic and concomitantly eating a bagel and listening to Linkin Park.

Another major drawback of digital computers compared with biological ones is that these are only as good as their programming, which is a hell of a task. The software that took Apollo 11 to the Moon had approximately 145,000 lines of code, the Mars rover Curiosity 2,5 million, and

Mac OS X 86 million [4]. So imagine if it would be possible to create computers that work out complex problems in similar ways as biological brains do, by self-assembling information and writing its own program to solve a particular problem.

In *Design and Construction of a Brain-Like Computer: A New Class of Frequency-Fractal Computing Using Wireless Communication in a Supramolecular Organic, Inorganic System*, this is exactly what Subrata Ghosh and Anirban Bandyopadhyay and co-workers describe [5]: the fundamental computing principle of a frequency fractal brain-like computer that does not need circuits or programming (Fig. 1). This organic "brain jelly" computer consists of protein-like particles that start to self-assemble, triggered by an electromagnetic signal (Fig. 1a). Essentially, this multilayered hierarchical self-assembly functions in the same way that proteins are assembled from individual amino acids to a secondary and finally to their three-dimensional and active form. In the brain jelly, self-assembly leads to the formation of a basic artificial neuron structure, with various three-dimensional nano-structured assemblies, i.e., wire, spiral, spherical, or semicircular assemblies.

Dr. Bandyopadhyay explains that, "*brain jelly is a chemical soup made in such a way that for any argument it learns, an equivalent nano-structure is formed that holds the argument. It learns arguments like, "if there is a rain, then take out umbrella". The vibration for "if-rain", say 15Hz, continues for more than a certain time in a nanowire, then the "then-take-out-umbrella" vibration of 30 Hz will take over in that nanowire. This we call transformation from "if" to "then" or decision making. The more arguments the jelly learns, the more materials self-assemble as connected nanowires. Eventually we get a network of nanowires. If we neglect the material, in abstract terms, it is a collection of vibrations in a giant 3D network. This jelly network is our computer. Any small 3D pattern of vibrations, if pumped into this network, first expands and all associated patterns start vibrating. Subsequently, transformation into the most associated pattern occurs, which is radiated out and captured outside the brain jelly as the final result of the input. Look at it this way: the input pattern contains our thoughts and the output 3D pattern is our decision. This is how brain jelly computes".*

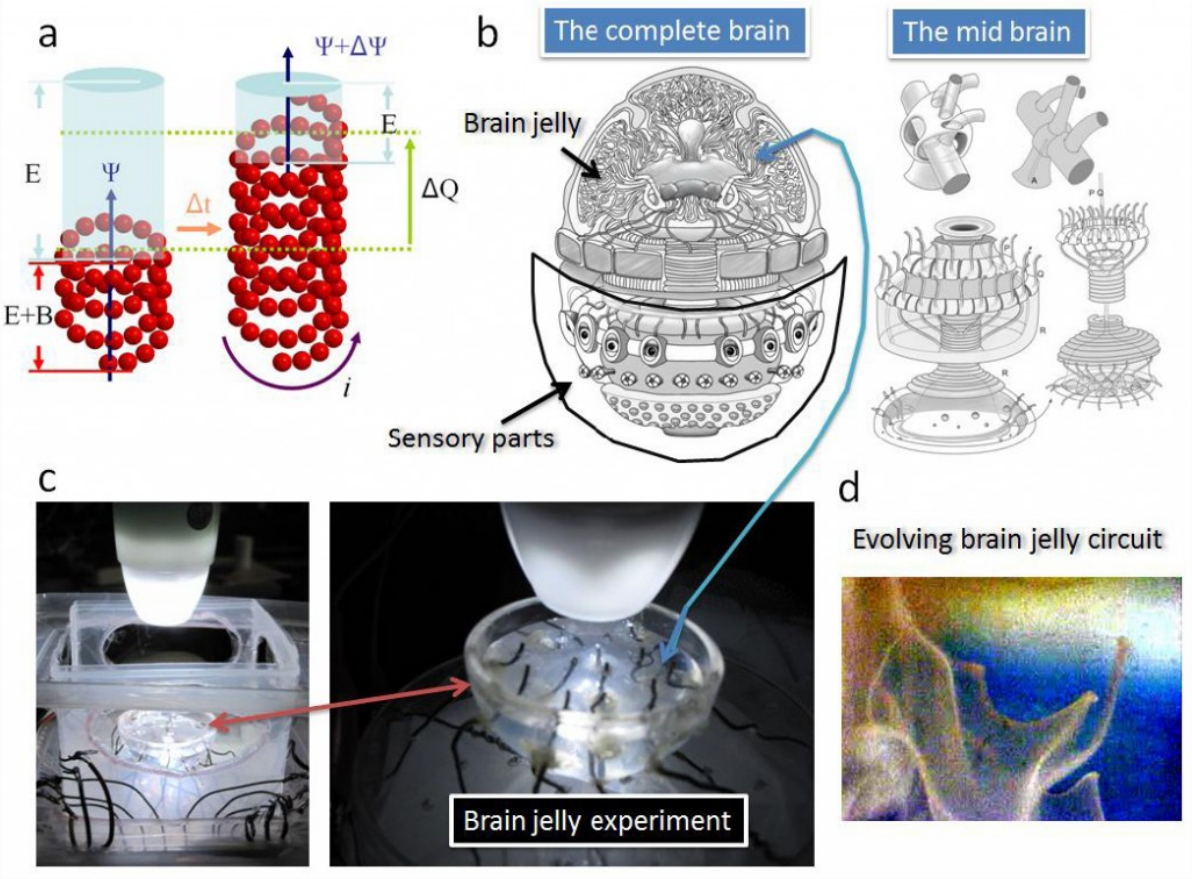

Figure 1. (a) Every single seed of the brain architecture has a helical symmetry just like the human brain; (b) The complete design of our organic supramolecular architecture based human brain. The egg-shaped complete brain has two parts (left), the upper part holds —brain jelly, the spinal cord and the mid brain is inside this egg, shown separately in the right. (c) The experimental set up where we study the circuit evolution of a brain jelly; (d) The microscope image capture of a video when 7 nm seeds create visible brain circuits.

I asked Dr. Bandyopadhyay how the functioning of the brain jelly compares to the way a human brain works.

"The architecture of the brain is like a giant oscillator and if we open it up, we find a large number of footballs inside. If we take any of those footballs, and look inside these, then we find millions of footballs inside. The journey continues and every football basically represents a string of vibrations; a string means, 15–30 –50–60–80 Hz. However, every football has an upper and lower speed limit, and therefore work as clocks. The entire network of footballs could be a clock inside a clock inside a clock, etc. Now, the smaller in size we go, the faster the clock becomes. When we measured the brain (pages page 67-68 [5]), we discovered this clock-like network, and we followed exactly this principle when we made the brain jelly".

You use a low watt energy source. Does that mean that the brain jelly only needs this low watt source to function even when handling complex problems, such as atmospheric

modeling, or would the power consumption increase the way it does in current supercomputers?

"We use an atto watt (10^{-18}) power source, which means that hexaFLOP computing could be done using only 1 watt. We harness the available thermal noise for our purpose. Secondly, we use wireless and resonant non-radiative energy transfer, hence we do not have power loss via energy transport, which is a big concern for the existing digital processors. Third, we do not have a 0 and 1 switch, it is a string of vibrations, and hence the coupled vibration link is never broken. Thus, operation of our computer, as explained above, would convert atmospheric modeling into a 3D network of pattern, which can be solved instantaneously. The whole idea of computing for us is instant reply-back with the solution and consequently, computing time is always constant. This is very different from supercomputing".

What is the advantage of the brain jelly compared with Turing tape-based digital computing?

"Digital computing means that if I give input x to a device, it would apply a function f on this value x, and return f(x) as a result. Now, unlike Turing tape, we do not use discrete arguments, which if written on a piece of paper could be cut into pieces and glued in a line to operate using a Turing machine. We have a network of arguments that if written on a piece of paper cannot be cut and glued, so it is not a Turing machine.

Then what is it? Is it a machine? Of course this is a machine, because it executes a command.

In a Turing machine, you need a software engineer to write an algorithm; here we do not need that. Our computer has only one highly interconnected single argument, just like a thread, and new arguments arrive there as a new thread and get connected at a suitable location in the massive 3D interconnection of arguments. Therefore, this is self-assembly of the argument. Secondly, Turing machines need wiring to connect discrete elementary operations. In the brain jelly, the entire input and output with the core hardware has to be wireless". What is spontaneous reply-back? "*In classical digital and quantum computing, if we want to find an answer to a question from 16 different persons, an algorithm needs to be written by a software engineer, wiring is necessary to connect components, and the question needs to be asked and processed one by one in classical computing or as a group in quantum computing. In brain jelly computing the question is asked out loud for all to hear and the person with the right answer replies back (spontaneous reply-back). Also it signifies that we do not have any wiring to address the switches one by one, which represents a radical shift from the existing world of computing".*

Does the brain jelly make parallel computing of complex tasks possible or is this beyond its capacity or future capacity?

"Computing time is constant irrespective of the complexity of the problem. This is how this computer would outperform any supercomputer. As previously described in detail, the computer solves 3D clique problems instantly, which means our computer actually finds a given 3D network of points in a massive 3D network of points. We convert all problems into this job, because this is the problem that our computer solves instantly, irrespective of the number of points in the 3D network".

What is the weakness of the brain jelly computer?

"The computer needs to learn and if it does not hold the entire database algorithms, it cannot solve a problem, because it stores information and decisions in a very particular way, and that is the key to its information processing and ultrafast speed. Therefore, it is just like specialized humans or engineers. We cannot expect Joe Average to explain Einstein's theory of relativity, even if we teach him. Hence specialization and preparedness is one weakness. The second weakness is that during training, it may not learn properly. In this case, the whole computer needs to be thrown into the dustbin. The third weakness is that, just like humans, it can make errors of perception. Finally, this computer is not good at solving simple problems and accuracy is significantly compromised; existing computers are much, much better in this case".

Finally, how do you envision that brain jelly-like systems will be used in the future?

"As noted in the paper, we have already provided the final design of an egg shaped computer (Fig. 1b) in which brain jelly will be injected; much like envisioned in Hollywood's "I robot" movie. Then, if you connect the brain jelly computer to the internet and define the basic task, the egg will start learning and become a master at the subject. If a situation is encountered where the database is so massive that it is impossible for a human to access all the data, this brain jelly computer will not only be able to access the entire data, but once it reads through all the data can answer new queries, even queries it was never taught. Thus, it will be a creative companion.

Data deluge is one of the biggest problems of the 21st century and our computer provides a robust solution to that. We expect massive chaos due to data deluge issues, since we are triggering complexity on a massive scale, in every aspect of daily life. Accidents might trigger and collapse entire systems and we would not have a clue what is going on. In these situations, our computer would work very efficiently. Capturing intelligence in a massive scale database and discovering hidden logic in such systems is the specialty of our computer. Creative decision making and answering queries that it never heard before is one of its key features".

Author Spotlight

Dr. Subrata Ghosh received his Ph.D. in organic synthesis from the Indian Association for the Cultivation of Science, India, in 2010, working on the total synthesis of biomolecules. Currently he is a postdoctoral fellow at the National Institute for Materials Science (NIMS), Japan. He has worked on molecular machine design and synthesis, dendrimer-based cancer and Alzheimers drug design and synthesis, and brain jelly is his brain child. He is an expert in neurophysiology and cell culture. He has given more than 10 invited lectures and was awarded the best paper award at the international conference on unconventional computing in 2010. He has published 14 papers in international journals and is currently writing a book on brain inspired computing. He is interested in the development of chemistry beyond chemical kinetics route.

Dr. Anirban Bandyopadhyay is a Senior Scientist at the National Institute for Materials Science (NIMS), Japan, and currently a visiting professor at MIT, USA. He obtained his Ph.D. from the Indian Association for the Cultivation of Science, India in 2005, where he worked on supramolecular electronics and multi-level switching. During 2005-2008 he worked as an independent researcher (ICYS Research Fellow) at the International Center for Young Scientists, NIMS, Japan, on brain-like bio-processor design. In 2007, he became a staff scientist at NIMS. He has developed the resonance chain-based complete human brain model that is fundamentally different from Turing tape. This is an alternate human brain map where filling gaps in the resonance chain is the key. He has developed a unique quantum music measurement machine and experiments on DNA, proteins, microtubules, neurons, molecular machines, cancer and developed a new frequency fractal model to establish an unprecedented world of physical biology squarely parallel to the chemistry-only biology existing today. His group has designed and synthesized several forms of organic brain jelly that learns, programs, and solves problems by itself for futuristic robots during 2000-2014, and several software simulators that write complex codes autonomously. He has received several awards, including the Hitachi Science and Technology award in 2010 and the Inamori Foundation award 2011-2012. He currently serves as an executive advisor to several international scientific organizations and works as an editor for different journals.

Bandyopadhyay Website

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