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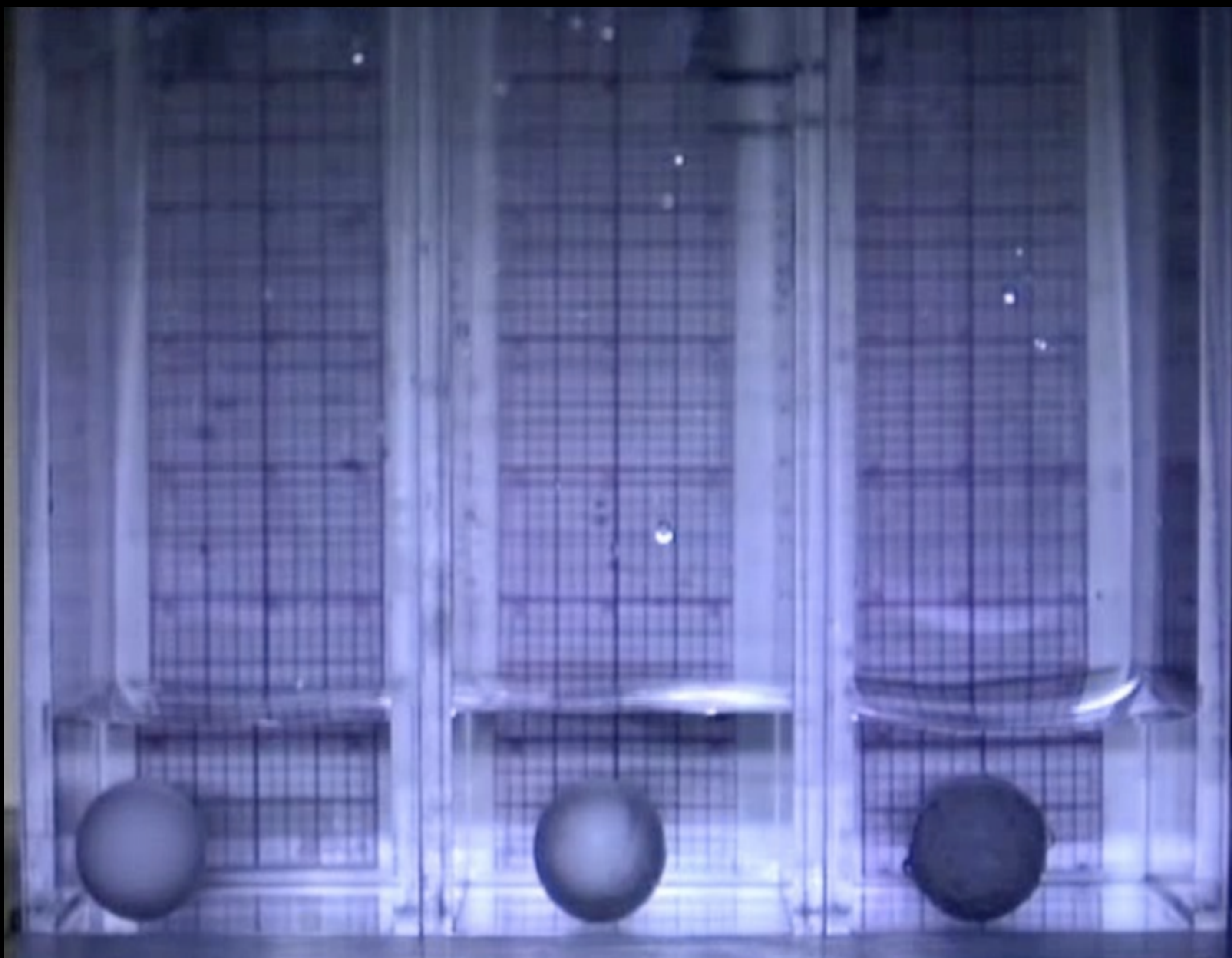

Expulsion Effect of Superhydrophic Materials

Editorial

Why to Study the Brain?

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The brain is the ultimate computational machine in the universe. Despite what was thought about the brain decades and centuries ago, now it is well understood that the brain is a calculator, a machine that does computational things. In other words the brain is something that takes information in its input, elaborates it and then spit-out some result in form of information or actions. Many centuries ago, the brain was the location of the mind. The mind was considered like a mysterious entity where our thought, our consciousness and our feeling resided. The definition of mind of course is still valid today, in some sense. What has changed is the fact that now we know that the mind is the results of a computational process. A very, complex process, presumably a stochastic one, but as far as we know, something that we can define as a computer "algorithm" is running inside our brains. Data are processes in a way that is not yet completely clear, and the result is our entire behavior, our thoughts our actions and our perception of reality.

In the last decades, we became aware of the mathematical properties of the only active element in the brain: the neuron. A neuron is a specialized cell that receives electric inputs from thousands of other neurons in different locations. It does a simple and reproducible process on these and gives out a response. What kind of response? An electrical spike, or better called action potential. This is a sudden surge of electric potential, followed by a quick fall of it. This behavior resembles a little bit the discharge of a small battery, as if we suddenly short-cut it. After the neuron has spiked its signal out, it needs about 5 milliseconds to recharge, then, if the conditions allow, it can spike again. This makes the neuron a very slow machine. If we compare it to modern transistors, the maximum spike frequency is a mere 200 Hz, whereas a transistor can be millions of times faster than that.[1] What are the conditions by which a neuron decides to spike ? Very simple they are: neurons integrate the thousands of electric signals coming in the input, and if the total potential is high enough they spike, otherwise they remain at rests. Of course, this is an oversimplified explanation of the mechanism by which a neuron works.

We have a complete and reliable mathematical model of the electrical functioning of a single neuron (for example the Hodgkin–Huxley model.[2] Actually, Izhikevich demonstrated that it is possible to construct an exact mathematical model of a neuron, simulate its actions numerically and compare the result with experiments with real biological neurons.[3] You can compare these results and have difficulties to distinguish what is a simulation and what is an experimental recording. Even if we have this quasi-perfect understanding of the functioning of a single neuron, our knowledge of how a brain works is limited. Let alone how the mind works, if we define the mind as the ensemble of our perceptions, feeling and conscious thoughts. Since the brain is simply an intricate network of neurons, the logical question is: why is that? Why we don't understand it? The short answer is that the brain is too complex. We know very well how a neuron works, but we do not know how the neurons are connected, and we do not know how the information is coded in the brain.

Many experiments on animals and human show us that perception is related and in some cases even proportional to neurons spike activity or spike rate. For example, we know that if we ask a subject to think about something, some area of the brain will consume more oxygen than other.[1] This means that in that region of the brain the collective neural activity is higher than in other places. Or, we can measure directly the electrical output of single neurons during particular tasks and discover that the firing rate of certain neurons correlates to a particular percept and not another. [4] Nevertheless, despite decades of efforts, we do not have yet a reliable theoretical framework on how the brain processes information. We are unable to reproduce the brain because we cannot make artificial brains in silicon. That's a pity because those would be millions of times faster and more powerful than biological brains. Our inability to do so, in some sense, is really astonishing because, after all, we are brains...! Despite of what said above, there is progress in Brain science. The most evident is the growing success of artificial intelligence algorithms. 2

New terminology as artificial neural networks, deep learning and machine learning are becoming common. These algorithms are not directly biologically plausible, but they are anyhow inspired on the brain architecture. The neurons are not modeled as spiking devices, but instead are simplified as mathematical entities that output a numerical value. The value is obtained integrating inputs coming from other artificial neurons in a similar way as that happens in real brains. These artificial networks have been studied by engineers, physicists and mathematicians for decades and now. With the help of faster and better computers, they begin to produce results that can be used in real applications. Nowadays, we have artificial neural networks that realize face detection, speech recognition, data classification, data prediction and other things with decent precision and reliability. Specialized neural networks with fancy names like convolutional neural networks, recurrent neural networks, long-short term memory neural networks, hierarchical cortical algorithms and so on are taking place and growing in popularity.[5] Some of the applications that are possible now, were impossible just few years ago and the progress is continuing at higher speed. Because of the increasing importance of the Brain functioning *Science Documents* is willing to publish research about the mathematical and theoretical aspects of it. Especially, we focus on Neural Network studies, theory on Brain functions and its possible applications. Moreover, theory of cognition and perception with new original experiments are also welcome. Brain is an extremely complex machine, still unknown and mysterious. To avoid unnecessary complexity, manuscripts should be concise and focus on better readability and clarity. Papers on *Science Documents* do not indulge in intricate details. On the contrary, they are brief with a clear goal and statement of originality in comparison to current state of the art literature. Typical articles should be of about 3500 words, 3-4 pages with sections (Introduction, Methods, Discussion and Conclusions). Looking forward for the advances on the ultimate frontier of science: the reverse engineering of the Brain!

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