

## Machines Like Us interviews: Hugo de Garis

Prof. Dr. **Hugo de Garis** is professor of computer science and mathematical physics at Wuhan University, China, where he migrated in 2006. He was formerly an associate professor of Computer Science at Utah State University, Utah, USA. His research area is "artificial brains," a research area that he has largely pioneered. He has lived in 7 countries and is the author of the following books:

a) ***The Artilect War: Cosmists vs. Terrans: A Bitter Controversy Concerning Whether Humanity Should Build Godlike Massively Intelligent Machines***, Etc Books, 2005. A Chinese version of this book appeared in 2007.

b) *Multis and Monos: What the Multi-Cultured Can Teach the Mono-Cultured: Towards the Creation of a Global State*, (finished writing, August 2007, looking for a publisher).

c) *Artificial Brains: An Evolved Neural Net Module Approach* (being written 2007-2008).

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**MLU:** *Welcome, Hugo. So nice to have you with us.*

**HDG:** Thanks for interviewing me. I think your site will become very popular, because you have filled it with interesting people. I spent several hours with it the first time I learned about it.

**MLU:** *You have lived in many countries for extended periods of time, and are in a unique position to compare and contrast the technological prowess of various developed nations. Until recently you lived and worked in Japan for eight years, where a lot of effort is being exerted toward building robots capable of helping their large, aging population. Now you live in China, with their incredible 10% annual economic growth rate, and have predicted that it will overtake the US as an economic power some time before the middle of this century -- siphoning off top US researchers by offering superior pay and benefits. Will China be the first to develop human-level artificial intelligence?*

**HDG:** It depends not only on whether China can attract the most talented AI researchers in the world to come to China, but more critically on whether it can KEEP them long term. Japan had its opportunity in the 1990s, when large numbers of western researchers (including myself) moved there to live. Now very few remain. Japan failed the "foreigner friendly" test. It is possible, but not certain by any means, that China might do the same, starting about a decade from now.

Western researchers and professors will not move to China in large numbers until it becomes a world class modern country, i.e., with rich salaries and having democratic institutions, with freedom of speech, not having the internet nor books censored, as is regrettably the case today. I calculate that China may become a democracy in about 10-15 years, based on the global trend of democratization. There are 120+ democracies in the world today (of about 200 countries). At the rate they are democratizing, there will be no more dictatorships left by about 2040. China is changing so fast that it will get richer and hence democratize more quickly than the very poor Arab and Black African nations, whose populations are often growing faster than their economies. Hence it will democratize in 10-15 years.

So if China becomes a modern foreigner-friendly state that is able to make talented foreign researchers feel welcome, then it can assemble the international research teams to build real A.I. this century. If China continues its incredible economic growth rate, then we will see a "brain drain to China" from the US and Europe heating up in about 10 years. (By about 2020, many cities in the east of China will have reached U.S. purchasing power levels, e.g., Shenzhen, Guangzhou, Shanghai, Hanzhou, Xiamen, Beijing, etc. Shenzhen, the richest city in China, is almost at that level today.)

**MLU:** *AI researchers often speak of their funding problems. You have said of the American university research grant financing system:*

*The American public is not sufficiently admiring of higher education to be willing to pay for it. There is a historical trend in the US that the percentage of the budgets of state universities that is paid for by state taxes is dropping. Raising student fees is one way to make up the short fall. Another is to tax the research grants of the professors more heavily.*

*Many US universities now take 40%, 50%, even 60% of the research grant money obtained by its professors to pay its heating bills, etc. As the state subsidy drops, the pressure on new professors is intense. US universities will only hire new professors who prove themselves to be good salesmen, i.e., good hustlers in scraping up money.*

*That's a sad state of affairs, and you cite it as one of the reasons why you eventually sought employment outside of the United States. What can the US do to promote a more nurturing environment for its researchers?*

**HGD:** For me, the short answer is that the US needs to "multify" (a term coined in my second book), i.e., become a lot more cosmopolitan, or multi-cultured in its mentality. The US has been globally dominant now for so long that it no longer bothers to look at other countries to absorb their superiorities. One rarely hears in the US media for example, "What do other countries think about...?"

Commercialist values are so strong in the US that even U.S. professors are corrupted by them. Europeans who are professors in the US don't appreciate this at all, so if China can offer them superior salaries and less commercialism, i.e., less stressful hunting of grant money, then they will leave the US to free themselves from it.

In my second book *Multis and Monos: What the Multi-Cultured Can Teach the Mono-Cultured: Towards the Creation of a Global State* I introduce the concept of the BRAD Law (Bit Rate Annual Doubling) of the speed of the internet. In 30 years, that's a billion fold speed increase, allowing the transmission of high resolution, richly vivid, 3D images.

Another idea is that of the "GloMedia (i.e. global media) Project," that would bring all of the world's media (TV, radio, etc) to all the world, i.e., everyone gets everything, leading to the development of a world language (English) and in time, to cultural homogenization and the formation of a global state. (There are today already some 50 trade blocks in the world, e.g., EU, NAFTA, ASEAN etc. that include as members, nearly all the countries of the world. A global state would be the next logical step).

Once the US gets GloMedia, Americans will be shocked out of their insular minded complacency, and will realize that Europe is surpassing them in many ways, and that the days of US global dominance are numbered (as must be the case, when China has 1.3 billion people and a 10% economic growth rate, vs. America's 0.3 billion people, and a 3% economic growth rate). Once the US government sees a clear indication of a brain drain to China, i.e., from the US, that will set off alarm bells, and motivate questioning why so many non-US brains have decided to leave the US for greener pastures in China.

One of the reasons would be due to the "tax collector" model of US university financing, as mentioned in the question. Other reasons would be, for example: the US being a rather unsophisticated middle class migrant culture, its religiosity, its brutality (no national health service, the death penalty, lax gun laws etc.), its insularity, its alienation, its dumbed-down media, its philistinism, its obesity, etc. (See my second book for the pros and cons of a handful of world leading countries).

If the US can become as interculturally sophisticated (via the GloMedia) as, for example, Europe, then it will become much more motivated to reform its institutions to make the US more attractive relative to China. This will be very difficult, due to the high level of insularity of Americans. It took the international TV cable and TV satellites (bringing TV channels to France from all over Europe) to jolt the French into recognition that France was nothing special, just another "also ran" in the European Union. The 1990s were painful for them as they came to terms with their "lost dominance." The infamous (and for Americans, insufferable) French arrogance, largely evaporated.

The US needs to go through the same painful process in the 2020s, and as a result make radical reforms to its culture, otherwise it will not be a player in the later 21st century. Too many people, like me (i.e., former US residents), will have voted with their feet and have moved to China. (I'm just one of the first little holes in the American dam.)

**MLU:** *For the benefit of readers who may not be familiar with your work, please give us an overview of your "brain building" research, which is based upon a process you call "evolutionary engineering."*

**HGD:** For about 15 years I've been dreaming of the idea of building artificial brains. In the late 1990s the Japanese lab where I was working, paid for the construction of a brain building machine (CBM) which would evolve neural networks at electronic speeds. The idea was to evolve 10,000s of these neural net modules, one at a time in the CBM, download them into its RAM memory, and connect them up according to the designs of human "BAs" (i.e. brain architects). The neural signaling of the artificial brain thus constructed would then be performed by the CBM in real time. The A-Brain (artificial brain) would be used to control the many behaviors of a robot kitten using 2-way radio control via antenna.

The development of this expensive machine (\$500,000 each, only 4 made) was stopped in its tracks due to the bankruptcy of the Brussels based lab I was working in during the dotcom crash of 2001. I then had to wait several years for Moore's Law to enable the same level of capability as the CBM in a much more affordable electronic board (e.g. the Celoxica board, only \$1500).

So in China I now have a team of about 10 people busily designing and evolving the many thousands of neural net modules for a 10,000 module artificial brain. This new method is cheap, quick and it works. So, expect artificial brains to be built in China, with an ever growing number of evolved neural net modules, over the next few years. In fact, my next

(third) book will be entitled *Artificial Brains: An Evolved Neural Net Module Approach*. It will show how to build artificial brains using the above much cheaper approach.

**MLU:** *Please describe the significance you assign to reversible computing.*

**HDG:** My first book, *The Artilect War: Cosmists vs. Terrans: A Bitter Controversy Concerning Whether Humanity Should Build Godlike Massively Intelligent Machines*, claims that massively intelligent machines are coming this century, and that probably there will be a major war over the issue whether humanity should build them or not. One of the critical enabling technologies leading to the creation of the "artilect" (artificial intellect) is 3D circuitry.

If an artilect is the size of an asteroid, for example, then obviously 3D circuitry is needed. But if so, how then to overcome the heat dissipation problem, i.e. how to get the heat out of a computing solid whose surface area is of dimension "length squared," whereas the volume is of dimension "length cubed"? If the volume is large enough, the heat generated will be too great to be dissipated quickly enough, so that the 3D computing material will melt, or even explode.

The answer to this problem is to use reversible computing, i.e., the computing approach that does not destroy bits of information. (**Landauer's principle** states that computer circuits generate heat by destroying information.) Research into reversible computing is now increasing, of necessity. Today's chips are getting hotter and hotter because they are getting denser but still use the logically irreversible techniques of the past, that wipe out bits (e.g., using (computationally universal) NAND gates, with their 2 bits in, and 1 bit out, destroying a bit at every operation).

So, in a sense, you can say that reversible (i.e. heatless) computing is the foundation stone of the creation of the artilects. If godlike artilects, with capacities trillions of trillions of times above human levels, threaten to be created this century, leading to a major war that kills billions of people (gigadeath -- the characteristic number of people that would be killed in any major late 21st century war, if one extrapolates up the graph of the number of people killed in major wars over the past 2 centuries), then that is important by anyone's judgment. Hence, the basis of it all, reversible computing, is significant.

**MLU:** *You have predicted that over the next half-century, such powerful economic and political momentum will be built up in favor of constructing intelligent agents that stopping the process will be almost impossible. Marshall Brain, creator of the popular How Stuff Works website, has similar views. In his on-line novel, **Manna**, he details a process by which ever more intelligent machines steadily replace our human work force, eventually creating rampant unemployment. You foresee an even more dire consequence for humanity, however, which you describe in your book, *The Artilect War*. What are the circumstances you envision that will cause this war?*

**HDG:** The book is very pessimistic, unfortunately, although I hope it is at least realistic. Its basic scenario is as follows. It is predicated on the rise of the "artilect," i.e., machines that use 21st century technologies such as 1 bit per atom storage, reversible, heatless, nano-teched, self assembling, (topological, i.e. robust) quantum computers, that will have capacities zillions of times above human levels. I foresee humanity then splitting into 2 (arguably 3) major philosophical groups, a) the Cosmists (in favor of building artilects), b) the Terrans (opposed), and c) the Cyborgists (who want to convert themselves into artilects by adding components to themselves, i.e. by becoming "cyborgs" (cybernetic organisms)).

The Cosmists will view artilect building as something magnificent, almost a "scientist's religion" in the form of "god building." The Terrans will fear being exterminated by the artilects, who might look on humanity as a grossly inferior pest. The Cyborgists will argue that the Cosmist-Terran conflict can be avoided by having human beings themselves become artilects. I see the Terrans being horrified at the idea of having their children cyborged and thus made totally alien. The Terrans will fear the idea of artilect building and hence will fear the Cosmists (and their artilects) and advanced cyborgs. (For a Terran, there is little difference between an advanced cyborg and an artilect, such is the astronomic computing capacity of nano-teched matter.)

The Terrans know that they cannot wait too long if they are to act, because if they do, then the artilects and cyborgs will become vastly superior to them and could easily defeat them, if needed. So the Terrans will have to "first strike" if the Cosmists are serious about building artilects. The Cosmists will anticipate such a strike and be prepared.

Since all this will be playing out in the second half of the century, a major war in that time would be using late 21st century weapons, and hence probably billions (not millions) of people will be killed. What is even gloomier is that most individuals are split more or less evenly in their sympathies towards Cosmism and Terranism, i.e., awed by Cosmism, and terrified at the prospect of gigadeath. So if we have a global state (world government) by mid century (as my second book predicts) the Artilect War would then be a global civil war, and very bitter, because the artilect issue so evenly divides people.

**MLU:** *Why continue to pursue brain building research if the consequences of doing so are so dire to humanity?*

**HDG:** If you are a strong Cosmist, you will place higher priority on the creation of godlike artefacts than the survival of the human species. Cosmists will be asking themselves "What is a single artefact worth in terms of human sacrifice?" "How many human lives would you 'trade' for a single artefact?" Implicit in the Cosmist doctrine is the acceptance of the risk (a key word in the "species dominance debate") that building artefacts might cause humanity to be destroyed.

Cosmists are prepared to take that risk. Terrans aren't, and in the limit, will prefer to kill a few million Cosmists in an Artefact War, so that billions of humans can continue to live risk free. For the Terrans, exterminating the Cosmists is the lesser evil, than the far greater evil of allowing artefacts to exist. If the artefacts are built, they would control humanity's fate, since they would be the dominant species. Humans would be powerless against them.

**MLU:** *One of the more speculative and intriguing ideas in your book is the premise that super intelligence may reside well below the elementary particle level. What do you mean by this?*

**HDG:** In the early 1990s I remember being at an MIT meeting on nanotech, with a phone line link to Erik Drexler in California. I asked him, what he thought about the prospect of a "femto-tech" (i.e. a femto meter scale technology that would use quarks, gluons, etc., to build femto-meter scale devices). He poo-pooed the idea, surprisingly. A femto-tech based artefact could outclass a nanotech based artefact by a factor of a trillion trillion (i.e., its density of components would be a million cubed times greater, and a million times faster).

If a femto-technology could exist (and I challenge readers to dream up possible ways to implement it, i.e., find suitable physics phenomena to enable a femto-tech), then that would provide another data point on the graph of "techs." If a femto-tech can exist, how about an atto-tech, and descending right down to humanity's smallest conceived scale of a "Plank-tech"?

If this can be done, then advanced beings, such as our artefacts, might be exploring technologies at increasingly smaller (and hence faster) scales. So we are led to the conclusion that at tiny, sub "elementary" particle levels, there may be whole civilizations living at scales we are not even aware of.

**MLU:** *It seems plausible that once the process of constructing artificially intelligent agents is mastered and they are mass produced, they would readily communicate with one another (given the prevalence of wireless communication today and its even wider use in the future, this seems inevitable). For the sake of efficiency -- if nothing else -- might they not eventually "merge" into a single, distributed intelligence?*

**HDG:** If you are going to have closely merged distributed intelligence, then given 3D circuitry, why not just put your network into one large creature, e.g. a large sphere of artefact material. Signal distances would thus be lower, so it could think faster. But if the underlying technology of the artefact is nanotech based (i.e., at the scale of the nanometer, e.g., storing one bit of information on one atom), then there will be a limit to how big the artefact can become. If it gets too big, it might collapse as a black hole. So one can imagine a network of large artefacts, communicating with each other, using signals.

I labeled such a network a "netilect" in my first book. These artefact "nodes" in the network could then specialize and hence form a single distributed intelligence, as you suggest. But, it would be faster to have the network nodes agglomerate into one big sphere. To do this, and to overcome the black hole limit to size, pressure would be on the artefacts to scale down, i.e., to find a physics basis for femto-tech, and smaller scales (e.g., string tech).

**MLU:** *One might argue that your work is part hard science, and part fantasy. While laymen may relish your predictions about the future, there are researchers who feel that such speculation is best left to the writers of science fiction. How do you address this?*

**HDG:** The hard science fiction that I enjoyed the most was "plausible future science" that had real awe inspiring vision, and was usually written by scientists themselves, e.g., Arthur Clarke, Carl Sagan, Gregory Benford etc. To dismiss ideas as "science fiction" is risky. Look at the amazing prescience of H.G. Wells or Jules Verne. I'm rather skeptical of people whom I label "CDs," i.e., "competent dullards." High intelligence and visionary creativity are psychologically independent skills, so that those few people who are both tend to find the lack of vision of the majority of the highly intelligent people irksome.

I'm smart enough to be a research professor (teaching grad students in computer science, pure mathematics and theoretical physics, to understand the principles of topological quantum computing, that is about to revolutionize computer science by making quantum computing robust and practical) and was born with a rather unusual level of creative vision. In practice, I tend to ignore the CDs and don't respect them. The people I admire the most are the intelligent visionaries, e.g. Darwin, Einstein, Turing, Feynman, Drexler, Moravec, etc.

**MLU:** *On the lighter side: You've stated that you have some 6,000 books in your personal library. How in the world do you manage to take them all with you, whenever you move to another country?!*

**HDG:** It's a major pain. Actually, I've never counted yet just how many books I have. In my 2 adjacent (100 sq. m.) apartments, all the available wall space is covered with bookcases. One prof estimated I had 10,000 books. One day I'll get around to counting them, to settle the issue. To move them all from the US to China in 2006, cost me \$15,000. Fortunately my Chinese university paid me back. I suspect that one of the reasons why I've been able to survive in 7 different countries (Australia, England, Holland, Belgium, Japan, US, China) is that I tend to live in my ivory tower of books and don't interact very strongly with my external environment. I find the virtual reality of books (and more recently the internet) more intellectually stimulating than the external world.