GIS in 20 Years: Where is the Future Taking Us?

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SUMMARY

As pointed out by the recent publications from researchers like Ray Kurzweil, John Smart, Vernor Vinge and Damien Broderick, the next years and decades are going to see a tremendous leap in technology due to the acceleration of performance of computers which are helping us developing new technologies and ever more performing computers.

This technology leap, along with increasing memory capacities, processor speed and miniaturization, will have huge effects on our daily and professional life.

This paper aims at launching a reflection about the middle term effects of this coming technology leap on the field of GIS.

RÈSUMÉ

Comme l'ont fait remarqué dans leurs plus récentes publications des chercheurs comme Ray Kurzweil, John Smart, Vernor Vinge et Damien Broderick, les prochaines années et décennies vont être témoins de grands progrès technologiques en raison de l'accélération des performances des ordinateurs qui nous aident à développer de nouvelles technologies et des ordinateurs encore plus performants.

Ce bond technologique en combinaison avec des mémoires numériques de plus en plus grandes, des processeurs de plus en plus en plus puissants et une miniaturisation de plus en plus importantes des composantes, auront de grands effets sur notre vie personnelle et professionnelle.

Cet article vise à lancer une réflexion sur les effets à moyen terme de ce bond technologique sur la géomatique.

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1. INTRODUCTION

The field of GIS is widely based on advanced technology; computers, GPS, digital sensors, etc. It would nowadays be very difficult to acquire data and process it, to produce any map or to deliver any land planning system without relying on the technology we have today.
We have seen a huge progress in the technology in general during the last twenty years. This progress has had a tremendous impact on how we accomplish our work today. We only have to think about the use of the GPS or the internet to realize how differently we do our work from twenty years ago.

Due to the acceleration of progress, as we will see, the next twenty years ought to experience even bigger changes. In this article, I would like to extrapolate the progress rate in technology to try to get a glimpse of what we can expect in the next twenty years in terms of technology and its impact on our disciplines. Although this exercise can be risky, as long as we remain modest and we see it as a starting point for further discussions, it can be quite interesting to try to get an idea about where the future is taking us.

2. ACCELERATING CHANGES IN TECHNOLOGY

2.1 Moore's law

The demonstration of Ray Kurzweil in his last book that technology not only does progress but that its progress rate is in fact accelerating is a good illustration of what has been known as the Moore's law for computers chips.

When Moore stated his famous law in 1965 (although the term Moore's law wasn't coined by himself but only later by Carver Mead), he observed that the transistor density on semiconductor chips was doubling roughly every 18 months. This exponential growth has proved to be quite constant during the last forty years.

But according to Kurzweil, the Moore's law is only the fifth paradigm concerning the computational systems of the 20th century; the price-performance of electro mechanicals, relays, vacuum tubes and discrete transistors computational systems have all followed the same exponential growth, as can be seen in figure 1. Every time a technology reached its limit, a new one picked up where the other had left. It is likely that the two dimensional technology of integrated circuits will reach its limit sooner or later as the size of its component will reach an atomic level.

According to Martyn Amos, the next paradigm should be three-dimensional molecular computing which is gaining the right development momentum to pick up from where the integrated circuits will leave. It is therefore realistic to think that the exponential grow will continue to govern the developpement of computer technology.

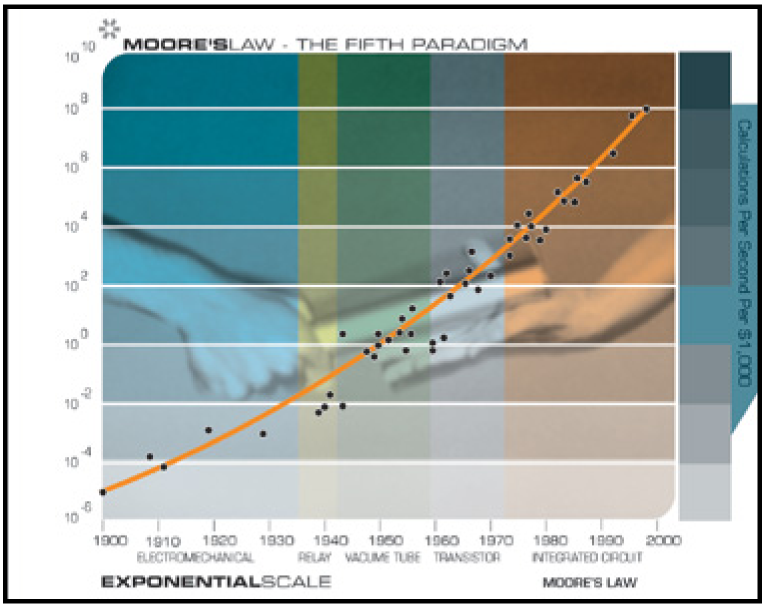

Figure 1: Moore's law: The fifth paradigm of accelerating changes.
From http://www.kurzweilai.net/

2.2 Extension of Moore's law to other computer components and other technologies

This exponential rate of change can be observed for other aspects of computer technology. The next table shows the doubling or halving time for some of them.

Technology	Time in years
Dynamic RAM (bits per dollar)	1.5
Average transistor price	1.6
Microprocessor Cost-per-Transistor cycle	1.1
Processor performance in MIPS	1.8
Transistors in Intel microprocessors	2.0
Microprocessor clock speed	3.0

Table 1: Doubling or Halving times (Kurzweil, 2005).

For example, if we take the microprocessor clock speed doubling time of three years and we apply it to the speed of the latest Intel personnal computer processor, the Dual-Core Xeon (3.0 GHz) and extrapolate it, we end up having a processor with a speed of around 384 GHz in 2027 which is more than a hundred times faster.

We can observe similar exponential growth for other technologies as well. It applies for example to magnetic date storage, to price-performance of wireless data service, to DNA sequencing cost in biotechnology, to the number of internet hosts, etc.

The trend that we can clearly see here shows that it is not wise to use a linear approach to try to predict what is coming ahead of us. The last 20 years can only be useful to infer the next few years. And accordingly, the next 20 years are going to see changes in technology far deeper than those we have seen for the last 20 years.

3. A GLIMPSE AT SOME COMING TECHNOLOGIES AND THEIR IMPACTS

In this section, I would like to present a few technologies that we can expect to appear within the next years and try to see what can be their impact on our professional lives.

It is of course quite adventurous to speculate about what technology will become mainstream and which one will simply not make it. There are many factors that come into account to determine whether a technology will make it or not. Apart from the efficiency of the technology itself there are all sorts of economical and social factors.

It is difficult to say if the technologies I will talk about here are actually going to make it or not and it is not my intention either. The intention here is to spark a discussion about the impact these technologies might have if they become mainstream. I chose to present a few of them but the discussion is also open to other technologies. The reason why I choose to present these ones is that they appear to me as interesting, diverse and potentially having a huge impact on our lives. The impacts I will talk about here can be diverse and will not only be experienced by GIS professionals but by everyone.

3.1 Robot Drivers

3.1.1 Description of the technology

The first breakthrough in autonomous driving came in the 1980’s with the work of Ernst Dickmanns and his team at Bundeswehr Universität in Munich. Their van was driving 100 km/h on streets without traffic. In 1995, Dickmanns and his team had their autonomous car drive from Munich to Copenhagen and back, a trip of around 1600 kilometers on the Autobahn, reaching 170 km/h in real traffic.

Later on started the DARPA Grand Challenge competition for robot cars. The 2004 edition was held in the Mojave desert region in US along a 240 km route. Unfortunately, none of the 106 teams were able to finish the race and the best team merely completed 5% of the total distance.

Nevertheless, the Grand Challenge was back in 2005 with 195 applicants out of which 23 were selected as finalist after the qualifications. This time 5 vehicles completed the race once again held in the Mojave desert region over a 210 km road.

Figure 2: Grand Challenge vehicle.

The 2007 and 2008 editions are planned to be held in a urban environment. The vehicles will have to complete a course of 100 kilometers while merging into traffic and observing traffic laws. It is going to be very interesting to see how many vehicles will make it to the finish line.

Now with all this developpement ahead, Sebastian Thrun, director of the Stanford AI Lab, predicts we'll have reliable urban robot driving by 2010, and that a majority of kilometers will be driven autonomously by 2030. Not wanting to get into the debate if this prediction is accurate or not, it can be very interesting to think about the possible implications of such a technology whenever it comes.

3.1.2 Possible implications

The implications of a technology that makes cars driving themselves are immense. First of all, it is very likely that once the right algorithms are implemented, autonomous driving will be much more reliable and less risky than human driving. There would be no more arguments about who is driving after having had a few drinks and this would bring a huge freedom to physically disabled persons like blind people for example.

Furthermore, there are 42 000 road fatalities each year in United States which are mainly caused by human errors. Although we too often witness error messages on our computer screens, they are still much less error prone that human beings. Autonomous driving might reduce by a vast percentage the accident rate.

On the environmental side, an autonomous truck fleet would consume much less fuel, whatever fuel we might be using by then, by driving at the optimal speed.

If we now come to the impacts of this technology in our field, the first one that comes to mind was brought by Thrun himself. He described an experiment he made with an aerial photo of a highway at its peak capacity at 4pm on a weekday filled with vehicles driving at 100 km/h. By analyzing the image he came up with only 8% of the road actually occupied by vehicles while the rest was free. This is because we human drivers need side and front distance with other vehicles consequent with our poor reflexes. Now if we replace human drivers with a mature technology that can drive our cars much more safely while being able to reduce the distance between vehicles, we could make a better use of the 92% free space on highways. I’m sure the urban planners will see the impact that road capacity increasing would have on their planning. This means a better use of existing roads, therefore preventing or at least retarding new road building.

It is the same with car parking. We like to park our vehicle not too far from where we go, therefore needing parking lots close to our working building for example. What if your car can drop you to the office and go park itself or pick up your husband from the sport club or go to the maintenance shop on its own? This could also have tremendous impacts on the way we plan cities. Instead of having to plan huge nearby parking lots, they could be planned a little bit further, allowing buildings on a university campus for example to be within a more walkable distance while the parking lots are further out.

3.2 Personal Nanofactories

3.2.1 Description of the technology

Another technology that could change many things if it someday becomes mainstream is the Personal Nanofactory. According to the Center for Responsible Nanotechnology (CRN), molecular manufacturing “might become a reality by 2010, likely will by 2015, and almost certainly will by 2020”.

Without going into the details of this technology, let’s just cite the Nanotechnology Glossary that defines molecular manufacturing as “the automated building of products from the bottom up, molecule by molecule, with atomic precision.”

A Personal Nanofactory or Desktop Nanofactory is a device that can build objects molecule by molecule from raw material following an assembling plan. According to Steve Burgess, “much of the raw material for most objects we commonly use can be found in air and dirt, with a few fortified materials thrown in.”

Much of the value of our daily life objects would then reside more in the information and less in the material needed to build them. Now instead of receiving by post the last 40 megapixels camera you ordered from Amazon, they would only send to you via internet the assembling instructions that you would feed into your Personal Nanofactory that would build it for you.

Figure 3: A artist view of a Personal Nanofactory.

This is actually the same principle as the fax machine; when you send a fax, you don't actually send the paper but only the information that is on it. Then the fax machine prints it on a piece of paper with ink, the raw materials, that are already on site.

One objection that could be raised about this device becoming mainstream and gaining general acceptance is that we still go and buy books, which are essentially information, despite the fact that we could print them on our printer. This is true but the main reason to this is that we like to hold a good old book in our hands instead of reading on a computer screen or holding pieces of paper together. If this is true for books, it doesn't hold for a downloaded camera as there would be no difference between the camera they deliver to you and a camera you download and have built right on your desk.

The main opposition is probably more likely to come from the industry itself. We all saw what happened to the music and the film industries whose products are mainly information and we all see how the printing industry learned the lesson and is protecting itself against this threat.

3.2.2 Possible implications

Now when it comes to the implications of this kind of device if it becomes mainstream, the first one that seems quite obvious is its impact on the delivery industry. If domestic products become deliverable via internet, this industry could suffer a big impact. But as the printer industry sells cheap printers but expensive ink cartridges, if personal factories need molecule cartridges to work as can be seen on the artist view of Figure 3, those cartridges will need to find their way to the device anyway just as paper and ink cartridges for printers. This is likely to depend on the industry itself.

But if we find a way to make nanoassemblers as the ones that will be needed in personal nanofactories, we may as well make nanodisassembler devices, in which we would feed any garbage we would otherwise throw away, to be broken down to the basic raw material needed for the personal nanofactory. This would have the huge advantage of cutting the amount of garbage thrown away. Some kind of a ultimate recycling process on a local level, like compost for the garden.

This could have impacts on urban planners when it comes to city waste management. First, the waste collection would be greatly modified since there would be much less waste. Then the dumps would become either smaller and/or would be used as raw material providers for nanofactories plants to build new things without having to extract new material from mines.

These new ways of using matter with their impact on environment and economy are likely to modify the GIS industry as well since most of the urban planning done is nowadays using GIS.

3.3 Miniaturization of GPS Receivers

3.3.1 Description of the technology

The question of GPS miniaturization is closely related to chip miniaturization and is likely to follow the same exponential curve. Many years ago, GPS receivers size only allowed them to be carried in a back pack. Recently, researchers were tracking pigeons using a GPS flight recorder of only 33 grams the birds carried on their back. One could say that while GPS receivers are still carried in a back pack, the size of the back has hugely decreased!

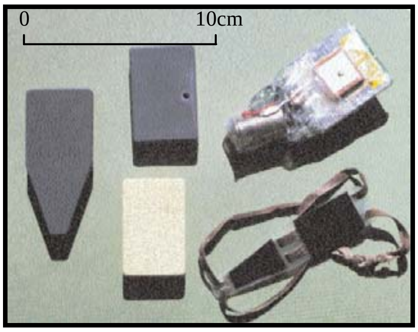

Figure 4: The parts of the mini GPS used to track pigeons.

This decreasing rate could lead to tiny GPS receivers coupled with data transmitters that could be incorporated in any small object, from credit cards to car key or pairs of glasses.

3.3.2 Possible implications

The incorporation of GPS receivers in any small devices we can think of can bring a feeling of being observed by Big Brother. Like any technology, it has its evil sides. On the good sides there are many possibilities though. This technology could prevent us from losing anything anymore.

In research fields like glaciology, such devices could be spread on moving glaciers to track their movement very precisely. In the same way, the tiny GPS receivers could be launched in tornadoes to model their behavior.

GPS receiver covered volcanoes could also be more precisely monitored. Actually, any phenomenon that needs a precise tracking can be surveyed by such technology. This way of doing remote surveying could greatly impact the way we work.

3.4 Other technologies

The list of coming technologies is very long and the discussion could go on. For example, some luxury cars have a window transparent display informing the driver of possible road dangers. Once computers and GPS receivers are small enough to fit on a pair of glasses, we can imagine a pair that displays information about your environment directly in the glasses depending on your position and orientation, provided by the integrated database, Wifi connection, GPS and compass. This augmented reality could be used to easily find an address or to display the birthday of the person you're talking with. This could also be used by field surveyors to retrieve relevant geographic information.

The BrainGate Neural Interface developed by Cyberkinetics Neurotechnology Systems is a system that consists of a sensor that is implanted on the motor cortex of the brain and a device that analyzes brain signals. The person on which it is implanted can use it to control the mouse movements of a computer. While it is only used for disabled people at the moment, further research could make it easy to implant to anyone who wants to use it. The user could then remotely operate any system at will, including field equipment.

There is also a lot that can be done to enhance the display of geographic data. One concern is to be able to analyse 3D data and holographic display can be of great help to achieve this. With such a data display, not only the user can see 3D data but she can also see it from different angles. While holography is not new, the increasing availability of 3D data makes it more relevant. The addition of virtual reality to this can enhance data exploration and visualization and help decision makers to have a better idea of the different scenarios they need to compare in order to take the best decision.

At the Stanford Singularity Summit held on the 13th of May 2006, Ray Kurzweil demonstrated a verbal translator that could make on-the-fly translations from and to English, German and French. While this was only a prototype, Kurzweil predicts that this could become standard function on cell phones during the next decade. If we extrapolate this to the decade after, it sounds reasonable to expect a Bablefish type of device that could translate any language we hear. Making business, including outsourcing, with any country could become easier as the language barriers go down.

4. CONCLUSION

Predicting the future is a difficult task. Especially 20 years in advance. For this reason I tried to stay out of the predicting game to concentrate on the effects of some technologies IF they become mainstream. The main purpose of this article was to initiate a discussion about the impacts these technologies could have on our lives. There is a whole range of possible impacts and they often multiply when many technologies are considered at the same time.

Among them are technologies improving data analysis. As data is becoming cheaper and more available, the bottleneck is not data acquisition anymore but data analysis and pattern recognition is certainly something that computers lack at the moment and that can be developed and used in data analysis.

It is important to get as many insights as possible from as many different people as possible in order to see more clearly what is coming. After all, the further we can see in the future, the better we can prepare to cope with it.

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BIOGRAPHICAL NOTES

Serge Bédard, born in Québec City in 1968, studied Geography and Geomatics from 1990 to 1996 at Laval University, Québec City, Canada.

He worked for six years in Canada as a GIS Programmer, Project Manager and Quality Control Manager, designing and implementing quality control algorithms for street level GIS database.

He then moved abroad to work in the Photogrammetry field as an International Project Manager in Germany and India, managing the cartography production as part of outsourcing operations.

Since 2004 he is working for the Münster based company Hansa Luftbild. He is acting as an on-site Project Manager based in Morocco.

Serge Bédard has more than 10 years experience in Geomatics, Spatial Algorithms, Project Management and International GIS Activities.

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