

Comparing and contrasting ethical problems in bio-informatics with computer ethics.

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The information world has in its half century of existence thrown up a wide range of ethical problems involving privacy issues, personal data protection breaches, societal and work issues, and new ways of undermining social order and culture.

To these issues can be added the emerging concept of a global village with, however, more visible discrimination and inequalities between the 'haves' and 'have nots', and a new political order where the military might of America, based on its digital weaponry, has made it the sole dominant superpower.

Certainly, recent developments in the bio-informatics field especially in the field of genomics and in the field of knowledge acquisition within the medical field point to ethical and moral issues similar to those which are the concern of digital researchers and which have as a focus the continued survival of the human species.

These issues merit a serious study from an ethical and moral standpoint of concerns implicit in their future development and which carry an ever-increasing risk of tainting or handicapping our future existence as a human race.

Bio-informatics still lacks the diagnostic tools to ensure that it can forecast the effect of its actions, especially when it tinkers with gene sequences and structures. Back in 1966, in my first excursions into computer programming we lacked the debugging and testing tools so essential to modern programming development. The only tool available was a memory dump of the whole program consisting of the sequences of 0's and 1's. Compare and contrast this to the hit-and-miss tinkering currently applied to the more than three billion base pairs, which comprise a human genetic map.

In debugging, we had the problem of where does one start his search in looking and putting meaning on those strings of zeros and ones. Where did the data end, which parts were controlling modules, and which

performed specific execution tasks on the data? We knew that the answer was in the mass of strings and ones, but how could you make meaning and sense to emerge from a long string of zeros and ones typical of any binary system?

We used to cut bits and pieces and try to execute them separately to see whether we could understand behaviour of a specific sub-program and possibly re-use it in a different situation. Little by little one managed to put together the different sub-functions and give meaning to the whole system.

How often did it happen that by misplacing just one bit, the whole program failed or produced unexpected results? Of course, what some of the experimentation people are starting to perform in bio-informatics is of a higher order of risk and verging on trying to play God. Can we afford getting things wrong and are we prepared to start such experimentation? At present we obviously lack the necessary diagnostic, testing and reverse engineering tools as well as a comprehensive understanding of the underlying biochemical structures and the way they react and operate,

One thing which is sure is that nature is more ingenious and economical than any human programmer can be so that certainly within those billions of bio-data strings there are some perfectly logical, beautiful and super efficient operational structures which one day will be decoded and deciphered.

As an information scientist it is perhaps worth my reflecting on some major discoveries and advances in the field of computing which no doubt are being mirrored in similar bioethical road maps. No doubt future explorations in the bio-informatic world will make the manipulation of biological data more controllable and less risky.

The first point to note is that it was quite a watershed when Boehm and Jacopini proved that only three control structures, namely, sequences, iteration and selection, were required to control a computer program. What are the basic canonical structures in nature, which control the production of human life? Certainly the rules must be there, but the sets of dimension which govern life production are certainly more complex.

The basic structures involved for example in the human process involve

no less than ten thousand proteins which trigger on and off production pathways, three billion base pairs and two million molecules involved, having the radix of base four strings. To these have to be added the dimensions of reaction times, temperature, and location in space and density. Also the means of process operation will be closer to that of parallel machine architecture rather than a Von Neumann sequential process. This makes for a puzzle of awesome complexity which will probably require much more than the half century to unravel, which was the time required to resolve many computing issues.

The ethical and moral issues involved in tampering with such a structure in a reality of incomplete knowledge raises many troubling questions for the ethical scientist.

A second major development in computing was to recognise in systems the role of modularity and interfaces, and the consequent 'divide and conquer' approach first promoted by Knuth and Niklaus Wirth in their seminal works on the art of programming. Certainly we are seeing this happen in the bio-informatic field with the current attempts to recognise functional structures that perform specific real world recognisable tasks. These sub-units will most likely start being utilised as structures in repairing human defects and as human spare parts well before the whole set of functional components are fully recognised and interfaced.

Stemming from this second point one has to recognise the importance of a clear separation of the data required to perform a function, its relationships to other data, and the methods which act upon it. In bio-informatics we are still struggling to identify the various inputs required for the successful implementation of a specific function, and often it is still a hit and miss action whether all the required information has been identified for the successful execution of a process. However, we know that base pairs make amino acids which result in proteins assembled by an RNA template. So that the similarity of the methodologies required with those of traditional computing makes for more than probable prospects of new life creations with all their ensuing ethical issues

The third point is that computing made big advances when it moved towards object orientation which recognised that one has to focus on specific functionality, the data it requires and the interfaces it must provide to communicate with other objects in order to allow that object to execute.

Looking at the well-specified functions of our organs, limbs and senses, there is no doubt that nature must organise its structures and operations in some similar way. Once we recognise the key factors which such body parts require, we will be able to focus on relatively very few areas of the genetic map and consider the rest as black boxes. This will allow for information hiding as well as allow re-use of specific objects such as the programming of new organs and limbs.

The fourth point is that nature seems to operate in a form of parallel processing, as is so evidenced in the function of our brain and sight organs. As computing people we are much less adept at understanding parallel machines than we are with traditional sequential machines. So in trying to understand the creation of life we will soon find ourselves handling a flow of concurrent operations for which we have less experience in handling and understanding.

Recent times have shown the importance of multimedia and virtual reality in simulating real world events and providing visual and aural cues. As computers get more powerful we are blurring the divide between what happens in the real world reality and the virtual reality – the world which the information scientist creates on his machine.

One might have observed that in the recent Gulf war a lot of gadgetry was utilised. From the operational point of view, to a viewer or player, there is hardly any difference between the controls a kid uses when playing a war action game zapping Klingons on his SEGA computer, and a military pilot using virtually the same joystick and panel control in his fighter cockpit. The consequences are of course very different when some very real mass destruction of life and property is inflicted on the enemies' camp when the pilot uses his joystick.

This blurring will make it very difficult in future for bio-scientists to resist the temptation of playing life-manipulating games on their computers which could at any moment be translated into real-world creations and aberrations.

There are other uncanny similarities, which are worth noticing. Programmers often comment out code which they no longer need, leaving it as junk code within the finished product in the same way that there are junk sequences within a genetic map. Programmers also leave partially

uncompleted code for development of a better system in a future revision. They also leave hooks for future updating of the system. Often they leave their own signature code for others to recognise their creation. Is there in the same way within our genetic map, pointers to our past existence and evolution, or perhaps hooks to our future evolutionary path? Has some God who created us left his signature within our life program?

These considerations lead to a plethora of moral and ethical issues, which in future will increasingly require the need of a legislator, the need to enact laws to control what is permissible and what is not. Failing this, we may shorten or distort the natural evolution cycle of existing life forms to the point where we will be swamped by potentially dangerous, new, aberrant life forms. Most of these issue will need addressing on an urgent basis and will require the employment and engagement of ethical experts to provide guidelines.

Some issues, which need addressing, include:

- The issue of data privacy and the extent to which an individual has a right to control his genetic information as well as disclose or not disclose it.
- The issue of the extent to which we can allow automation of the processes of analysis and synthesis of bio-information to take place without overall human supervision. Increasingly we find that automata and robots are being assigned and carrying out the tasks of analysing and manipulating bio-information at a pace which leaves no time for human reflection of the consequences. This will lead, as happened in the case of the genome project, to an accelerated rate of information generation concurrent with less time for rational and ethical analysis. Bio-information scientists must control such advance and take hard decisions on what is morally and ethically acceptable.
- The issue of ever improving data analysis and data matching and discrimination tools is creating a new breed of ethical problems. Data-mining tools are constantly improving, and coupled with ever-increasing amounts of bio-information will enable us to discriminate better between beneficial and damaging traits in our genetic makeup. How are we going to preserve our individuality in such a situation and preserve what may initially appear to be unwanted traits?

If DNA Decode projects like the Icelandic one becomes more universally applied what will be the consequences? Will pattern analysis on such data condemn certain ethnic or other groups of people to second class designation to the extent that one may decide that certain genetic types are not worth procreating? What if military warfare scientists start creating designer chemical agents which will attack only those having particular genetic characteristics? Would this be the ultimate weapon of racial and ethnic cleansing and destruction?

Certainly the computing world has led to a rapid increase in our ability to handle and exploit huge amounts of data. In the case of bio-informatics, this points to the urgent need of creating more general awareness of ethical and moral concerns, of providing a higher order of professionalism for researchers in this area, and superior codes of conduct and practice in dealing with bio-information. There is the need of constant monitoring of an evolving scenario where quick action will have to be taken as new risks emerge. There must be new ways of handling rogue behaviour by a few irresponsible researchers and the establishment of a global authority similar to the Atomic Energy Commission to monitor all activities on a global dimension to ensure that proper sanctioning and logging is kept of all activities.

Certainly these new and exciting challenges ahead require us to take note and perfect our ethical frameworks in line with scientific advance

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