Manuscript

2014-08-20

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Leaving Traces – Words on the Road

Speech at the Inauguration of a statue

Linköping, August 20, 2014

Linköping's great son - Tage Danielsson - once explained, with his characteristic irony, that accidents in nuclear reactors are so extremely unlikely that they actually never happen. This is also how I feel to day : the probability of one day being able to participate at the inauguration of a statue of yourself is so small that I find it difficult to believe that it has happened.

However, if it *has* happened, and if you make a visit to the statue, you should be able to see that it contains some inscriptions on the ground or roadway that the statue person is walking on. My topic now is to explain the meaning and the background of those inscriptions.

They came about because the sculptor, Johan Malmström, invited me to select some words or phrases that could be placed on the statue, and I have then selected five dictums or expressions that have been inspirational for me for a long time. I call them "words on the road", "ord på vägen" in Swedish, and for background I should tell our foreign visitors here that in Swedish language, just as you can give someone "one for the road" meaning a drink before departure, you can also give someone "a word for the road" or "word on the road" meaning something to keep in mind during the journey. So the inscriptions on the base of the statue, the road that the statue person is walking on, are intended as such "words on the road", both for the occasional passers-by, and for the students that start their scientific journey here.

The first one of these phrases is from the title of the concluding work of Galileo Galilei,

> `Discorsi e dimostrazioni matematiche, intorno a due nuove scienze`

which means "Discourses and Mathematical Demonstrations Relating to Two New Sciences." This work is a very important one in the history of science for a variety of reasons, but the reason for my interest is maybe particular. As you know, I have been active during the early development of computer science as a *new science,* and I have seen how it is not merely a spin-off from an existing science (such spin-offs happen all the time). Computer science is a fundamentally new science, and then it's interesting to study earlier situations where radically new sciences were defined.

I am preparing a written note about this topic, but let me mention the two main points here. First : Galileo proposes not one, but two new sciences, but in the article he does not specify them by name or in any other clear way. Commentary in the history of science usually just say that Galileo was a founder of modern physics as an empirical and experimental science that uses mathematics to formulate its findings. Some identify two specific areas that are covered in this article, namely, kinematics and strength of materials. Another, tantalizing, interpretation is that this article is fundamental for both natural science and engineering science. This may or may not have been on Galileo's mind, but it is true that this article as well as Galileo's other works have been fundamental, not only for physics, but also for engineering sciences.

Then what about computer science ? It is of course an engineering discipline, since it deals with design principles for a certain class of structures and mechanisms, namely, data structures and computer programs. But should it also be considered to coexist with an empirical science, in the same way as Galileo introduces physics and engineering concurrently ?

I think the answer is yes, or at least it should be yes, and that the empi-

rical counterpart in our case is a field that ought to be called information science, although with a different definition than the usual one for that term. The empirical science that I have in mind is one that includes the field of knowledge representation, as well as large parts of cognitive science, and of computational linguistics, and of so-called semantic web studies, and several others. Taken together, these may constitute an empirical discipline or interdisciplinary area where we study the structure of information on the level of concepts and relationships, not merely as sequences of bits, as in information theory.

My second point is that Information science in this nonstandard sense is complementary to the empirical science that Galileo advanced, in an interesting way. Galileo used a classical distinction between the "primary" and the "secondary" qualities of objects in the world, where primary qualities are intrinsic ones such as velocity and temperature, properties that the object has in itself, and secondary qualities are the ones that an observer assigns to them. He wrote :

> "I think that tastes, odors, colors, and so on are no more than mere names so far as the object in which we locate them are concerned, and that they reside in consciousness. Hence if the living creature were removed, all these qualities would be wiped away and annihilated"

One may add that the observer-assigned secondary qualities will also include the classification into different types of objects and the relations between objects, so they are the concept-level information that is important in many parts of computer science, and that is the object of study in information science.

To summarize : Galileo and his contemporaries introduced the focus on what they called the primary qualities of the world, and on the use of mathematics for describing those qualities, and as well they introduced the synergy between fields of science and fields of engineering. This has been enormously important during the almost four hundred years since then. In our epoch, we can begin to see the emergence of a similar tandem between an engineering field and an empirical field, namely, computer science and information science, but here it is the secondary qualities of the world that are at the center of interest. To my mind this is a developent of long-term historical importance.

In this perspective I think it was both appropriate and fortunate that the name of our department, which we decided more than 30 years ago, was chosen as the *Department of Computer and Information Science.* There were also other reasons of a more temporary nature for the choice of this name, but we can see now that it's a name that is in line with long-term perspectives.

The second "word for the road" is a quotation from our great countryman Carl von Linné, or Carolus Linnaeus, who wrote

> Omnia mirari, etiam tritissima

which translates as "Everything deserves attention, even the most trivial and mundane". This is a good advise when it comes to software development and to software documentation, where the devil lurks in all the details. However it is more profoundly relevant in the formally based variety of information science, and here I must return once more to the connection

with Galileo. He characterized the scientific method as consisting of three steps, which he called resolution, demonstration, and experiment, successively. (The term demonstration here refers to the demonstration of mathematical arguments). The first step, which he called resolution, should be understood as *organized observation.* Organized observation may apply to a small set of phenomena, but quite often it requires a large set of observations, as done for example by Tycho Brahe, the astronomer, as well as by Carolus Linnaeus himself, and by many others.

In information science, organized observation and structuring is represented by the construction of large knowledgebases, and factbases, and ontologies, and semantic dictionaries, all of which are needed for bringing concept level knowledge closer to being formally understood. The knowledge that is captured in these knowledgebases is trivial and mundane for us. It is exactly the trivial and mundane information that it is such a challenge to come to grips with, especially when it occurs in very large quantities – and hence we need to remember "Omnia mirari", do not disregard something merely because it seems to have a trivial character.

I come then to the third "word for the road" which is also a well-known one, this time from Descartes, or Cartesius, who introduced the cartesian coordinate system, but who also formulated the dictum

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Cogito ergo sum
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meaning *I think, therefore I exist.* The reason why Descartes was interested in this composition of two obvious statements was that in his philosophy, and following the principles laid down already by Aristotle, he wanted to eliminate everything that could possibly be questioned, in order to arrive at an irrefutable theory. To begin with he needed one single statement that could not be doubted, and that would be used as a solid point of departure for his continued investigation. This enterprise reminds in a way of the one by Galileo, I think. The Routledge Encyclopaedia of Philosophy makes the following statement :

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In beginning with the Cogito, we build a philosophy
detached from history and tradition.
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and this is of course analogous to what Galileo did. I like the phrase 'cogito ergo sum', not only because it tries to build a conceptual framework from first principles, but also because it represents the ultimate in reflexive thinking, that is, thinking about your own thinking, which is arguably one of the necessary requirements for intelligence in the machines.

One of the well-known objections against the Cogito argument is that the existence of an 'I' is assumed in the first part of the dictum. If you say "I think" then the existence is assumed right there, so the statement assumes what it claims to prove. Maybe so, but I would like to turn this argument around : the phrase Cogito ergo sum reminds us that thinking as we know it *requires* an agent, an 'I'. This is what makes it so fascinating from the point of view of artificial intelligence. I have proposed that the concept of 'software individuals' is going to be crucial both for artificial intelligence and beyond. By this I mean software artifacts that have an identity and that are able to understand, and to reason about their own identity, as well as the identity of their peers.

If Descartes' argument is to be taken seriously, then these software individuals should also be said to 'exist'. And this argument would be valid even

if the computation in them were to be distributed over several pieces of hardware in the so-called cloud, and even if many other individuals would execute in the same cloud at the same time. So is this compatible with our notion of 'existence' ?

My fourth quotation is from a work in a Nordic language, namely the Icelandic Edda, which contains this well-known verse

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Deyr fé,
deyja frændr,
deyr sjálfr et sama;
ek veit einn,
at aldri deyr:
dómr um dauδan hvern.
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The first three lines here remind the reader the his cattle will die, meaning that his worldly assets will run out, and that his kinsmen will die, and that he will die himself as well. These somber observations would seem to be just as undoubtable as the Cogito that Descartes used as his starting point, but of course they are a lot more concrete. (Actually, religious systems of thought are often based on these premises). Anyway, the unknown poet then states that he knows one thing that is never going to die : *ek veit einn at aldri deyr,* namely, a person's posthumous reputation. If we translate this to our academic reality, it suggests that your final CV will stay on forever, and maybe the same will apply to the reports from the evaluation committees of your research projects.

These thoughts may be encouraging, or scary, but I would like to add another meaning to the phrase *Ek veit einn at aldri deyr,* namely, that science itself will never die. Think of it : Empires and civilizations have come and gone, since the dawn of science as we know it, but science has persisted and it has been passed on from one generation to the next, and from one culture to the next. It is driven by the natural curiosity of human beings, and it survives because of our ability to transmit scientific insights to those that come after us. This is the greatest thing about being a scientist : the work that you immerse yourself in contributes to an edifice that will live on and that has a permanent value. And that is really worth one's lifetime efforts.

My fifth and final quotation is not on the statue, since this might have been misleading. It is a dictum that is used in some formal contexts by the Royal Swedish Academy of Sciences, namely

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För efterkommande
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meaning *For those who come after us.* This simple phrase was adopted during the early years of the Academy, since it was formed with the explicit goal of harboring research that has practical utility, such as Linnaeus's expeditions for example.

This all reminds us that there are two different reasons for pursuing science, namely to satisfy our natural curiosity, and to do something useful. These two reasons apply both to individuals, and to the entire society, and it is usually said that these reasons go hand in hand : if science and scientists are just allowed to pursue their scientific goals, which tend to be curiosity-driven, then the useful practical applications will be obtained sooner or later.

The curiosity argument applies to the empirical sciences, since we want to

find out more about the world, but it applies as well to engineering sciences. The desire to *construct things* also seems to be an innate characteristics of humans, as witnessed by the construction of hunting traps and pyramids for example. And research in computer science contains many examples of where people built software systems that did things that no program had ever done before, and more or less for the sake of trying.

But the results of research are not always beneficial, so one may argue that the dictum *för efterkommande* should not only be seen as an encouragement towards what we are anyway doing, but also as an admonition to think about its long-term effects, although it is very difficult to sort out what are the beneficial effects, and what are the detrimental ones. In this context I think of a statement by the new archbishop of the Church of Sweden, Antje Jackelén, who has said about religion, in her case, that its proper role is to ask questions, and not to provide answers. For us as researchers, since it is virtually impossible to properly assess the effects of research, I think the right attitude for us also is to ask the questions, and to think hard about what the answers may be, and then to act according to your conscience.

What kind of questions ? Questions about anticipated negative effects of science often concern the violent use of its results, for weapons and in war. But when it comes to information technology we must also consider its possible use for another type of invasion, namely, for the invasion of privacy. We need another type of questions, another *question schema* to use our jargon, that concern privacy invasion. What has been the effect of e-mail technology on human privacy ? What about the use of electronic payment systems ? What has been the effect of search engines, such as Google ? What about unmanned vehicles on the ground, and in the air, so-called drones ? What will be the effects of the so-called cloud technology that is increasingly being used ? What about automatic language understanding and translation ? What about knowledge understanding systems ? What about artificial intelligence ?

No one has convincing final answers to these questions, and it is easy to conjure up both optimistic and pessimistic predictions with respect to these ongoing developments. That is why I would like to interpret the dictum "För efterkommande" as an admonition to continue asking these questions and to discussing the possible answers. Or in short, let's just think of what we are doing.

Turning back now to my new statue – I am very happy with it. And I really appreciate having had the opportunity to highlight these inspirational quotations by having them inscribed on it. I hope that many people will read them, that they will get their own ideas from them, and maybe begin asking "why are these quotations here, what are they doing in this context ?" I have added some speculation of my own in my interpretations of these quotations, and the visitor may or may not agree with my ideas, but hopefully he or she will also relate to the inscriptions by asking questions and thinking about the answers.

This statue has a very interesting title ; it is called *Leaving traces.* This is shown physically by the footprints on the ground in the statue, which you can see there together with most of the quotations that I have talked about. Maybe the artist - Johan Malmström - wanted to suggest that I have been leaving some traces, but this will be for others to judge. What I would like to read into it, from my point of view, is that the statue person is guided

and inspired by the traces left by those that walked the road before him.

This is something that applies to every scientist. There is this well-known phrase that we can do what we do because we stand on the shoulders of giants, but actually I think the observation that we as scientists are leaving traces is also very much to the point. We are not standing still when we do science, we move ahead, we search our way ahead, and while doing this we leave traces, but we are also led by the traces of those that researched before us. I want to thank Johan Malmström for this fascinating concept as well as for its realization as a statue, and for our interactions when it was prepared.

But most of all I want to thank IDA, as represented here by Mariam Kamkar, for having given me the honor of being elected a statue person, and for having acquired and mounted this very nice statue.

And finally I want to thank you all for having come here for this inauguration event.