The 3-rd Israeli Conference on Robotics,
10-11 Nov. 2010, Herzlia, Israel

It's Cognitive Robotics, Stupid…

Emanuel Diamant
VIDIA-mant, Israel

Our conference is ***The 3-rd Israeli Conference on Robotics***

"What is Robotics?"

- It is generally agreed that Robotics is the art, the science and technology of robot design.

"And what is a Robot?"

- This question does not have a consensus answer.

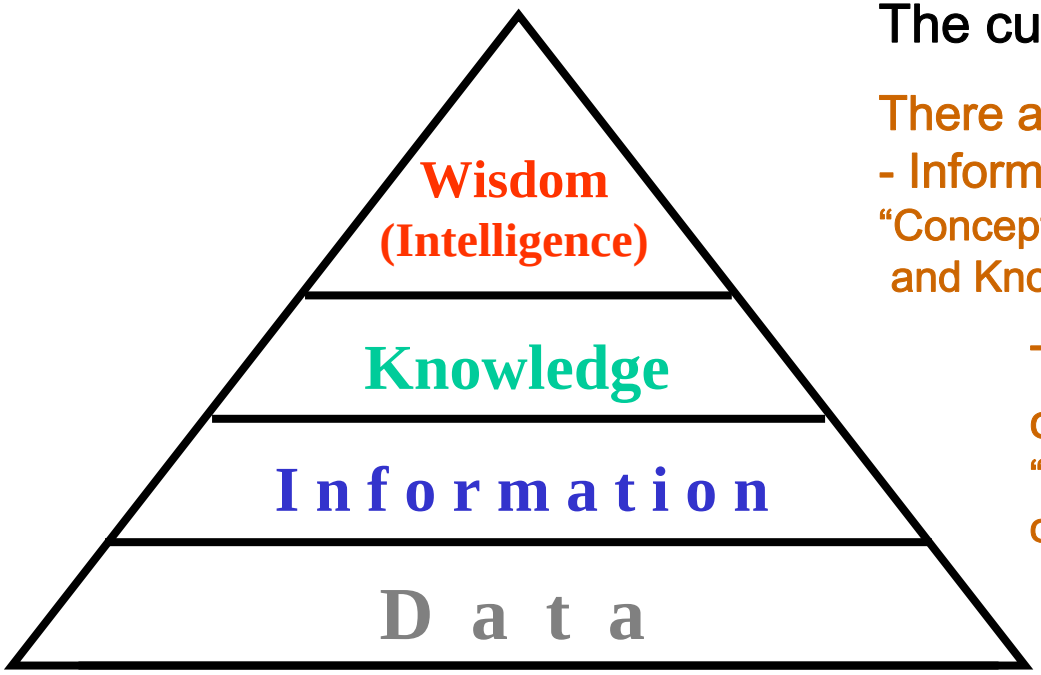
It's more easy to agree that the next generation of robots would operate in close coordination and cooperation with their human team-mates.

To facilitate this collaboration, robots would have to possess some human-like features and capabilities usually designated as **Intelligence and Cognition.**

What does that mean? –

Nobody knows.

I will argue that this lack of proper definitions is the main reason why the field of research in Artificial Intelligence (and some of its subfields like Cognitive Robotics, e.g.) has been derailed for the last 60 years. The definitions that are in use today are derivations from The Data-Information-Knowledge-Wisdom pyramid ("The DIKW Hierarchy", R. Ackoff, 1988).



The current state of the art looks like this:

There are more than 130 definitions of Data - - Information - Knowledge notions (C. Zins, "Conceptual Approaches for Data, Information, and Knowledge", 2007).

There are more than 75 definitions of Intelligence. (S. Legg & M. Hutter, "Universal Intelligence: A Definition of Machine Intelligence", 2007).

The multiplicity of definitions means only one thing:
an agreeable definition suitable for Robotic designs does not exist.

Therefore we are forced to create our own definitions. Here they are:

Data is an **agglomeration of elementary facts**. Some structure is always present in data aggregations. Two types of such structures could be distinguished – primary (or physical) structures, which arise from the similarity between nearby data elements, and secondary (meaningful or semantic) structures, which reflect the relationships between different primary (physical) structures.

Information is the **description of structures in data**. Considering the statements just given above, two types of such descriptions have to be taken into account – Physical Information and Semantic Information.

Knowledge is **memorized semantic information.** Not a higher level of information, not a different kind of information. Simply – semantic information kept in the system's memory.

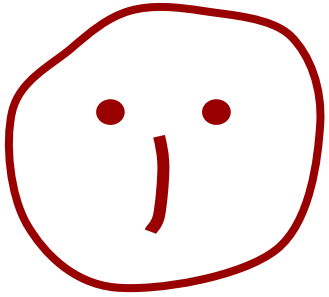
Intelligence is the **system's ability to process information**. Cognitive capacity (Intelligence) of any system is definitely determined by its ability to process information. This assertion is applicable to all natural (biological, living) creatures and artificial (robotic) systems as well.

The key point among these innovations is the new definition of information. To relieve your objections to it, I would like to reveal that this notion of information has been borrowed from the well-known papers of Solomonoff, Kolmogorov, and Chaitin published in the mid-1960s.

In this regard, we can learn from Kolmogorov's Complexity that:

-Information is a description, a linguistic description of data structures.
-Information is a hierarchy of different level description details.
-Information hierarchy evolves in a top-down coarse-to-fine depiction manner.
-Information is a composition of two interacting but non-intermixing constituents: physical information and semantic information.

As an example of an information description I would like to quote a kid recite:



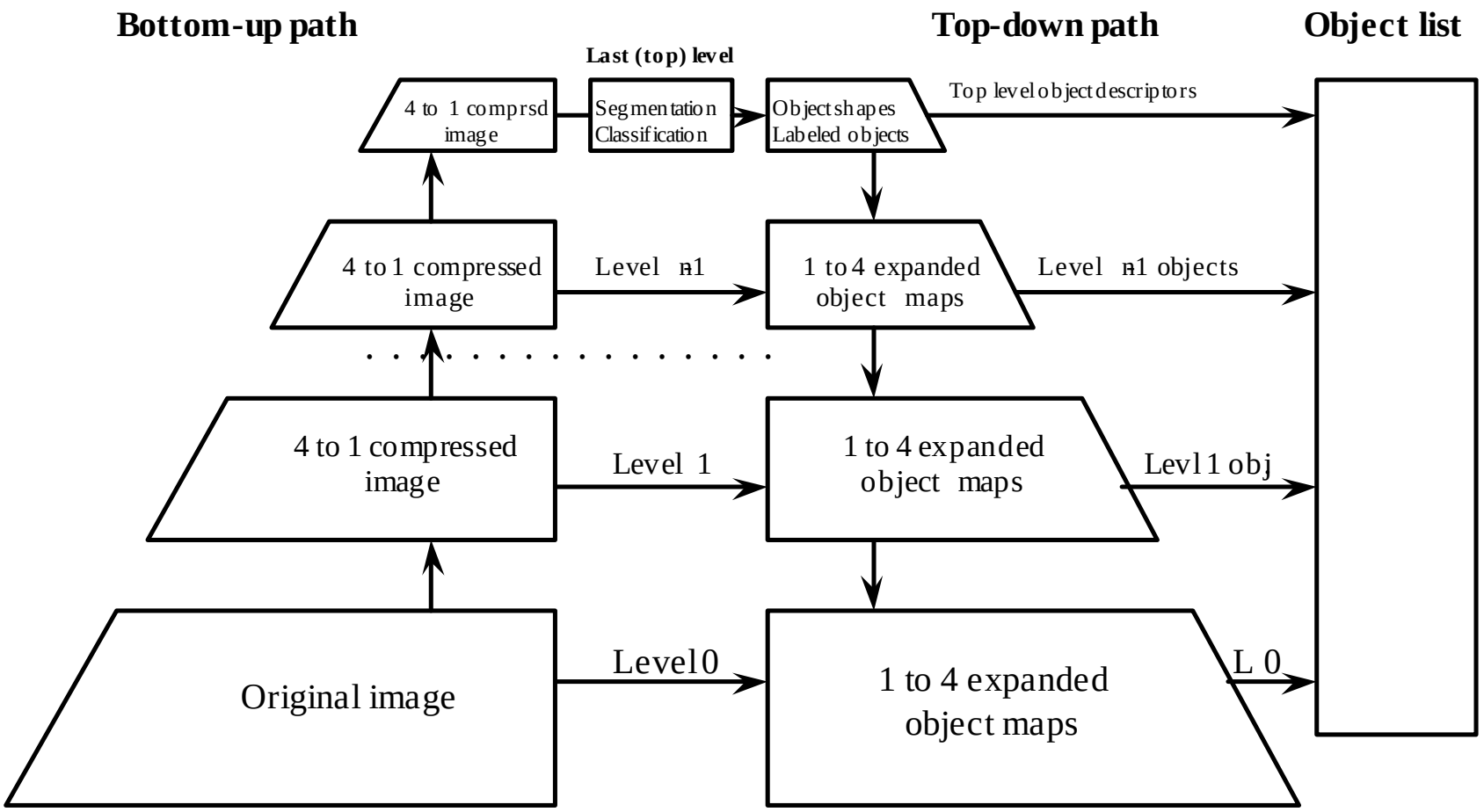
"Two dots, a comma, a circular trace,
And here you have a human face."

"Two dots, a comma, a circular trace" – is physical information,
"This is a human face" – is semantic information (a declaration).

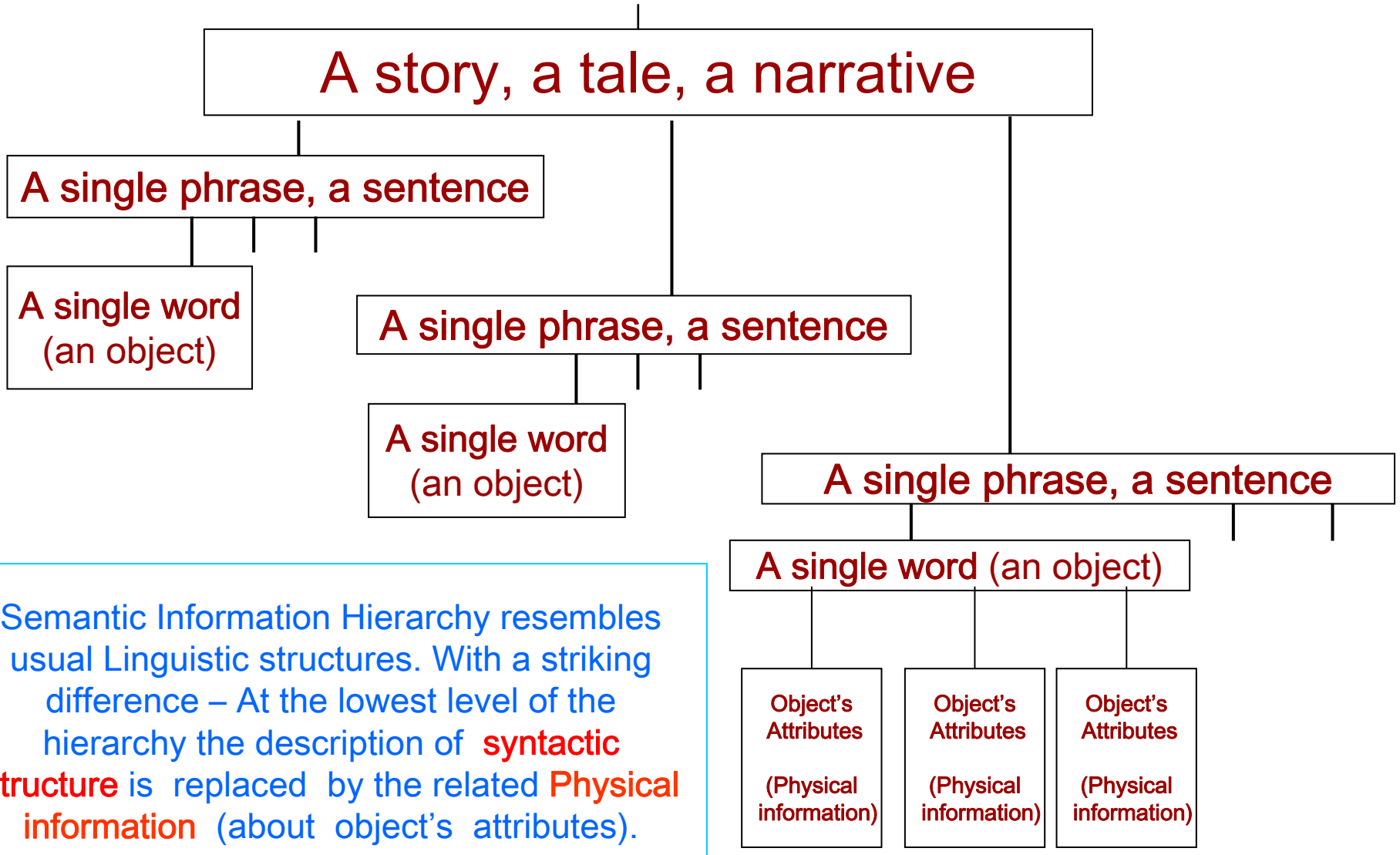
Inspired by Kolmogorov's ideas, I have proposed the following ways of information processing:

Physical Information Hierarchy

(for a visual input data)

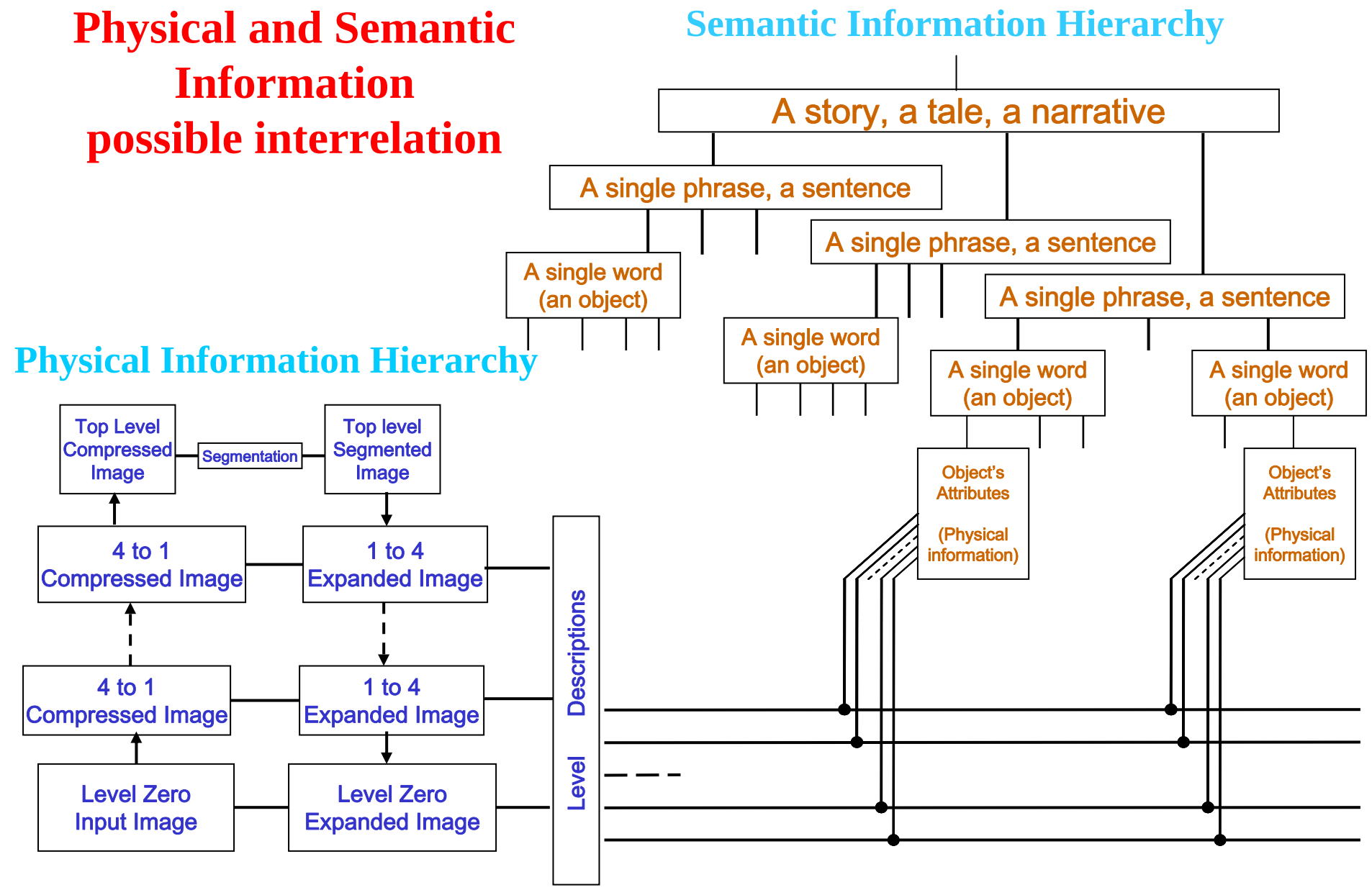


Semantic Information Hierarchy



Semantic Information Hierarchy resembles usual Linguistic structures. With a striking difference – At the lowest level of the hierarchy the description of **syntactic structure** is replaced by the related **Physical information** (about object's attributes).

Physical and Semantic Information possible interrelation



What follows
from this new information processing approach?

- Physical information is extracted from the input sensor data (in a top-down fashion).
- Semantic information must be preserved within a system (in a top-down fashion)
- Semantic information is always provided for the system's disposal from the outside. Therefore it can not be learned or be created within the system.
- Semantics is a property of an external observer. Consequently, it is not a property of the data and therefore can not be extracted from it.
- Physical information interpretation (understanding) comes as a result of associating physical information with the system's previous knowledge (with the lowest part of semantic information retained in the system).

Physical information processing implies a **"data processing" paradigm** which can be, and without any difficulty is, implemented on conventional computers.

Semantic information processing (due to the linguistic nature of semantic information) requires a new **"information processing" paradigm** which is completely different from data processing and therefore can not be implemented on a conventional computer (as yet).

What stems from the above conclusions?

- Semantic information is a mutual agreement, a convention, a shared arrangement between members of a specific observer group (Obviously, a robot can be a part of such a group). Therefore, semantic information can't be accessible to any who is not a member of a group. Therefore, semantic information can not be derived from the available data and can not be learned from data in any way or by any means.
- Considering Robotics as a data-processing computational task is a fatal misunderstanding that has derailed its development for more than 50 years.

These are the main flaws that Artificial Intelligence (in general) and Cognitive Robotics (in particular) usually hold as their first design principles. We can only regret that.

Here are some examples of such misunderstandings

European Commission Document "ICT Work Programme 2009/2010, (C(2009) 5893)" in its "Part 4.2 Challenge 2: Cognitive Systems, Interaction, Robotics" specifies as a problem that Robotic systems have to cope with **"extracting meaning and purpose from bursts of sensor data or strings of computer code…"**

This is a false and a misleading statement

– sensor data does not possess semantics, and therefore meaning and purpose can not be extracted from it.

DARPA's Document "Deep Learning" (RFI SN08-42) states that: **"DARPA is interested in new algorithms for learning from unlabeled data in an unsupervised manner to extract emergent symbolic representations from sensory input…"**

Again, that is a false and a misleading statement

– symbolic representations (semantics) could not be learned from data.

Sorry, but any attempt to reach such a goal is doomed to **a failure**.

Thank you for your patience

(further reading – http://www.vidia-mant.info)