Consciousness in mixed systems:
merging artificial and biological minds via Brain-Machine Interface

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There is not too much place here....
Further discussion?
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What do we expect from BMI?

to expand human capabilities by merging with technology

Why to merge? Here is a short list of what technology can do and humans can not:

- to perform a huge number of accurate calculations in a blink of an eye - the gift only rarely given to human
- incredible memory capacity – digital devices are able to remember immediately - without any rehearsal - and store for indefinite time huge amounts of information without losing a tiny detail
- richness of perception provided by hi-tech sensors far exceeds what our existing biological organs allow for
- traveling at high speeds, flying, diving deep into ocean and flying high to cosmos is beyond limits of human bodies

How to merge? The crucial point is creating appropriate interface between artificial devices and brain. Even if we are going to improve body capabilities, not necessarily mental, brain should be able to perceive and control this new body!
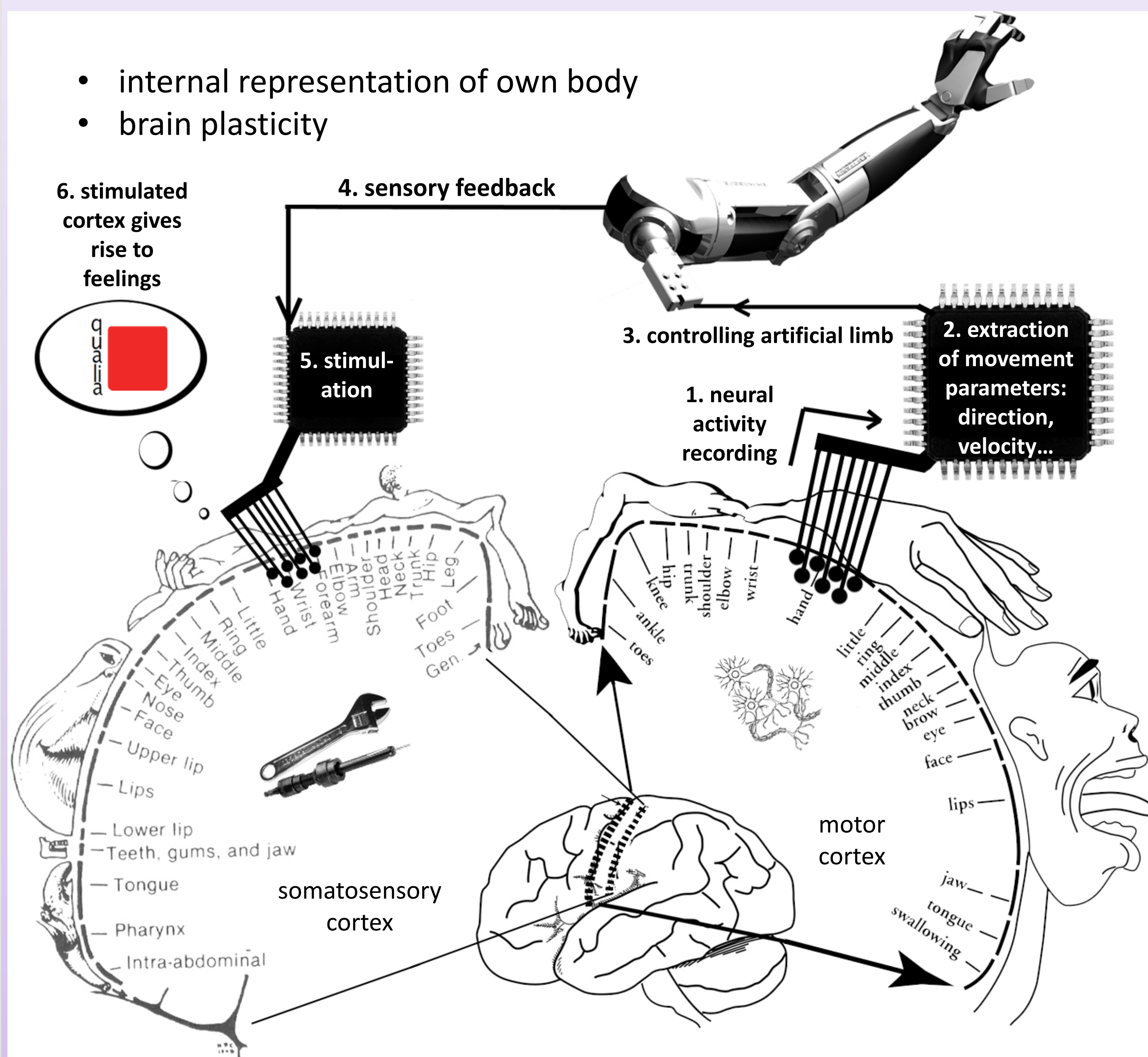
Brain-Machine Interface have been a common sci-fi topic for many years. Recently, however, science made a big progress, and now BMI is a target for many scientific and engineering projects.

But **can current BMI approaches** really bring us the kind of technology we expect?

A current approach to BMI

… is to rely on existing brain capabilities!

- internal representation of own body
- brain plasticity

6. stimulated cortex gives rise to feelings

4. sensory feedback

5. stimul-ation

3. controlling artificial limb

1. neural activity recording

2. extraction of movement parameters: direction, velocity…

somatosensory cortex

motor cortex

Brain contains direct neural representations of our body, one in **motor cortex** – for controlling movements, the other in **somatosensory cortex** – for feeling the body.

Due to **brain plasticity**, external objects such as tools and artificial limbs can be incorporated into this internal body schema.

This approach eats up precious brain resources and can be too limited – imagine learning to control 100 hands

A "Conscious" BMI

Brain can turn out to be too limited to manage a body - or several at once - more advanced than human. For this task a next-generation BMI can itself contain additional neural or some other kind of intelligent substrate. This looks reasonable - even brain has two separate hemispheres for managing each side of the body.

What is interesting here is that sensory components of our BMI should also be "conscious", so we can feel the artificial body. This is a striking difference from BMIs that provide sensory feedback by stimulating different parts of the cortex, because latter is based on already existing in the brain neural substrate that can produce conscious experiences. In proposed model, we are not eating precious resources of existing substrate (because they may be limited), but rather add new resources by adding our own components. But then these components should be developed with support for generating qualia, like their biological counterparts.
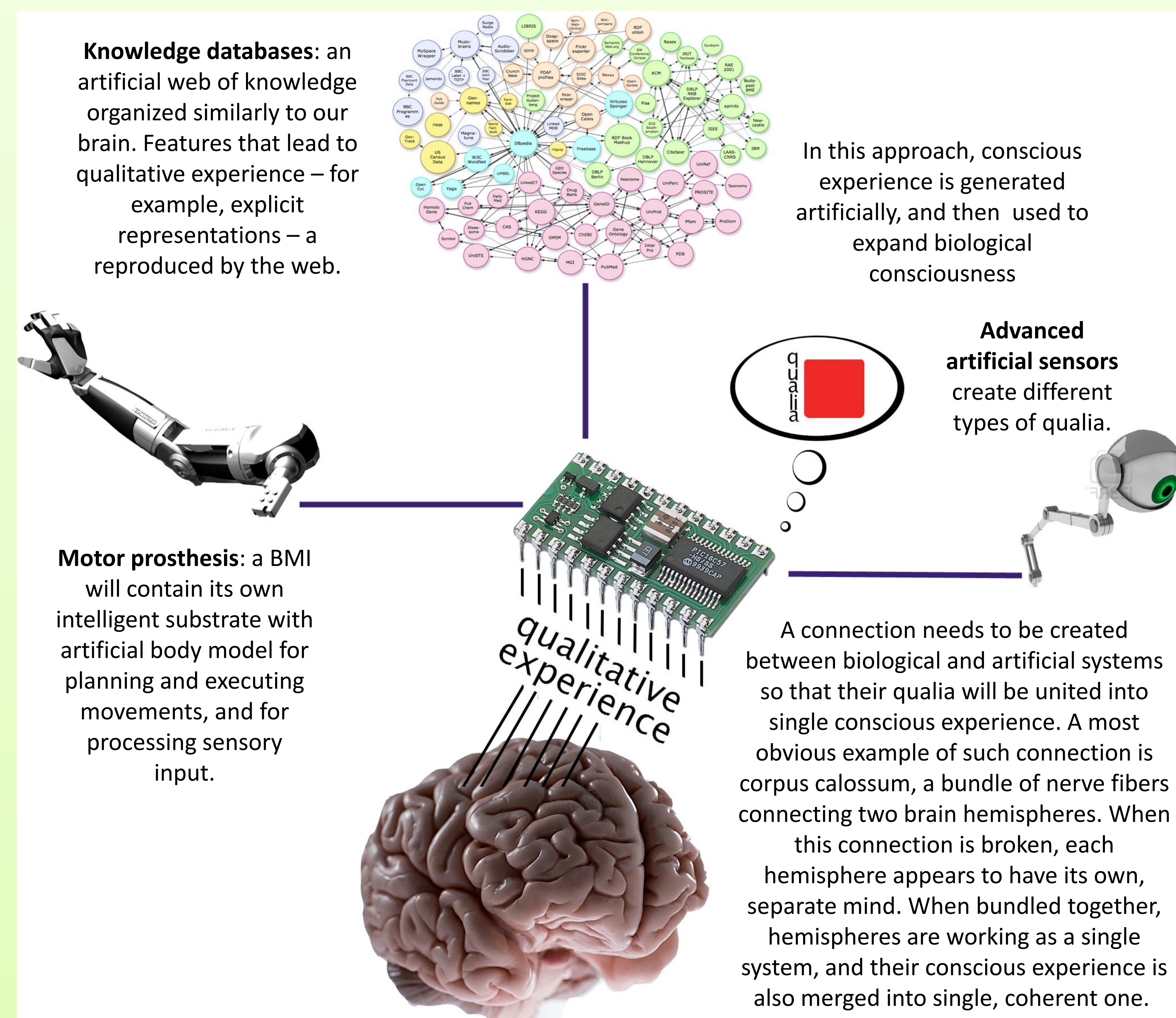
Knowledge databases: an artificial web of knowledge organized similarly to our brain. Features that lead to qualitative experience – for example, explicit representations – a reproduced by the web.

In this approach, conscious experience is generated artificially, and then used to expand biological consciousness

Advanced artificial sensors create different types of qualia.

Motor prosthesis: a BMI will contain its own intelligent substrate with artificial body model for planning and executing movements, and for processing sensory input.

qualitative experience

A connection needs to be created between biological and artificial systems so that their qualia will be united into single conscious experience. A most obvious example of such connection is corpus calossum, a bundle of nerve fibers connecting two brain hemispheres. When this connection is broken, each hemisphere appears to have its own, separate mind. When bundled together, hemispheres are working as a single system, and their conscious experience is also merged into single, coherent one.

Is this model possible to build from technical point of view?

According to some theories of consciousness, a high degree of interconnectedness within system is needed. This is hard to achieve, at least with modern technology.

But this needs to be done if we want to truly expand our capabilities – otherwise – no matter how advanced technology is – but we'll be always limited by what our brains provide.