Visions of IoT
I. Humans

Fundamentals of Internet of Things

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Disclaimer

- most of the ideas here are extracted from [Rose, 2014]
- however, any mistake should be attributed to the author of these slides

Next in Line...

Clarke's Third Law

Any sufficiently advanced technology is indistinguishable from magic

[Clarke, 1984]

Humans and Their Objects

New (sorts of) objects

- human needs are far from being just material
- there are *drives* that steer humans and their behaviour
- where the objects we invent and design and use play a fundamental role
  - they always have
- what if we do have *new sorts of objects*?

Material Objects

Objects and human culture

- *material objects* express our response to human needs
- they embody the carefully-designed answer to those needs
- including features such as their usability
- evolving over time, following ever changing individual and social requirements
- tools *embody* an essential part of human *culture*

Matching Human Imagination

Not just for engineers

- *designers*, *business strategists*, and *technologists* have to envision new scenarios
- possibly completely original ones
- matching user *imagination*
- what humans would *desire*, rather that what they do think possible

The Future of Computational Technology

Computers of tomorrow

- how are they going to *look*?
- *where* are they going to be?
- will they resemble anything we know today?

Special-purpose Computational Items I

Special-purpose tools

- humans have lots of material tools they do depend upon
  - swiss-army knife being more or less the only one without a clearly-designed single purpose
- screwdrivers, hammers, pens, hair driers, fridges, ovens, . . .—they do have a *special single purpose*
  - driving their design and most of their uses

General-purpose computational devices

- most computational items nowadays are (sorts of) *general-purpose devices*
  - workstations, portable computers, mobile devices
  - different, yet each of them aimed at addressing a hugely-wide array of diverse user needs

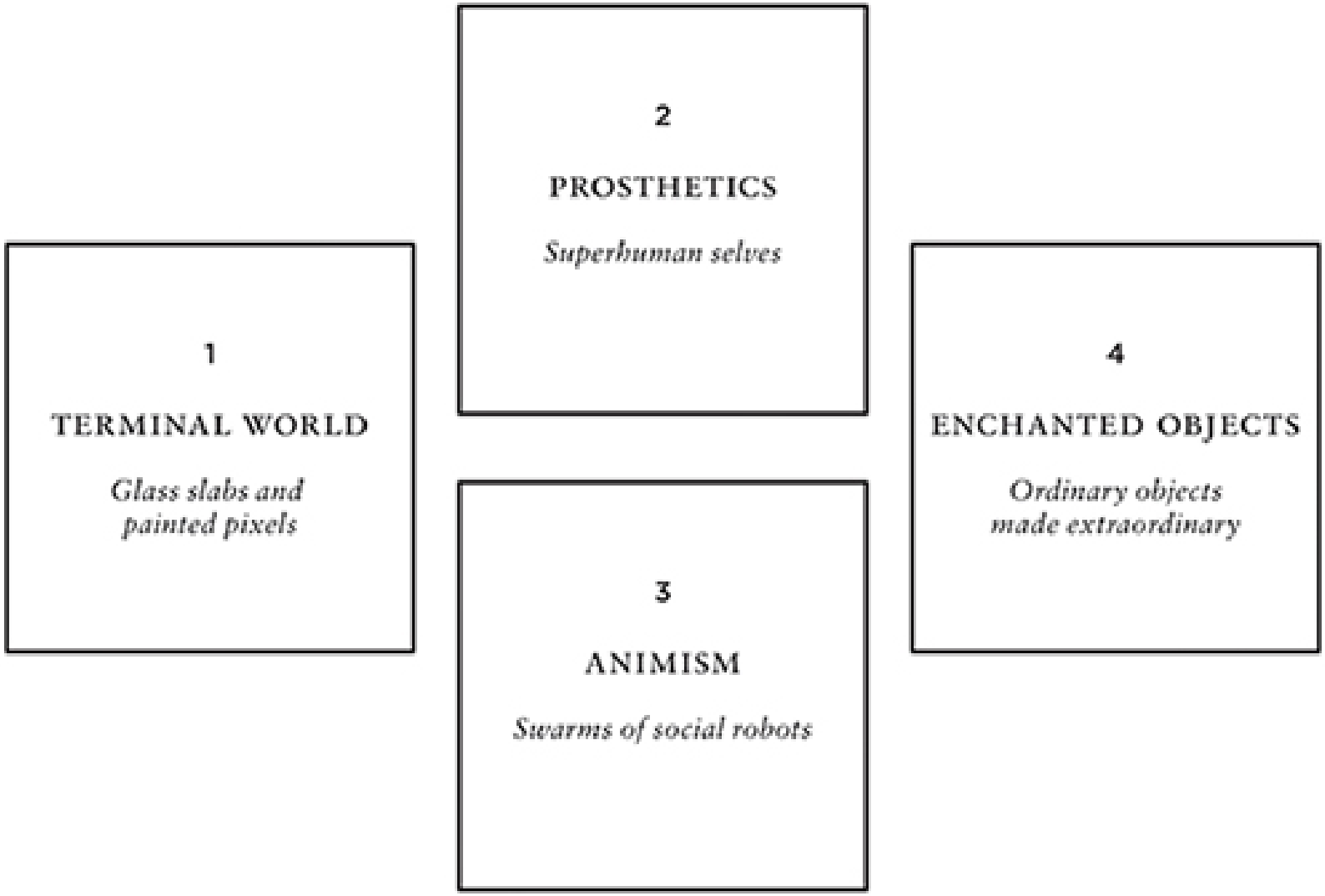
Special-purpose Computational Items II

Special-purpose computational objects?

- what happens when everyday objects acquire the ability to compute?
- should they be just host a general-purpose computational model
  - as, e.g., smartphones do...
  - or, as they do in some sense
- in other terms, the question is
  - should objects adapt themselves to host general-purpose computation, or
  - should instead computational models *specialise* to the hosting objects?

Next in Line...

Four Views of the Future [Rose, 2014] I



Four Views of the Future [Rose, 2014] II

Terminal World — that is, how everything goes through the same *screen*

Prosthetics — that is, how to patch and *improve humans* through technology

Animism — that is, robots, *humanoids*, when technology resembles us humans

Enchanted Objects — that is, when everyday objects behave like *magic*

Focus on...

Technology Legacy

Computers and their screens

- *computerisation* of human (individual and social) activities and processes
  - including industrial processes—e.g., control process
  - e.g., WfMS [van der Aalst and van Hee, 2002], CSCW [Schmidt and Simone, 2000]
- every portion of a process is visualised, monitored, and controlled through *computer screens*
  - e.g., big screens at a airport passenger terminal
- in the same way early mainframes were controlled via green-screen *terminals*

Technology Overdrive I

Personal smart devices dominate application scenarios

- basically everything passes through an app
- mostly through the (touch) screen
- every interaction, every service, every user's need
- if you are not there, you (and, your business) are nowhere

Technology Overdrive II

The push of personal smart devices is self-reinforcing

- everything is an app in a smart device
- everyone needs a smart device
- users think more and more that whatever they need to do, they'll do via smart devices
- whatever your business, you know that you need to squeeze it within a smart device, behind a touch screen

Technological innovation focusses on smart devices

- the number of *sensors* in smart devices is growing constantly over the years
- artificial intelligence in HW and SW within smart devices
- augmented reality [Furht, 2011] via smart devices—e.g., in games

General-purpose Devices

Computers and their screens

- interface is uniform
- information is all on screen
- interaction is the same whatever we read or write—more generally, whatever we perceive or do

One ring to rule them all

- general-purpose devices absorbing all the functions we need or like
- one single (sort of object) for all functions
- all of them more or less the same in terms of material, shape, physical perception and manipulability
- we have a single Swiss Army knife encompassing all of our cognitive and practical needs—including entertaining and social interaction

Questions

- benefits are obvious
- what about the drawbacks?
- what are the issues of general-purpose solutions to specific problems?
- more precisely, are we ok with the "Terminal World" future where almost everything is represented by coloured pixels upon a flat screen?
- are our specific features as humans really accounted for here?
- are "smartestphones" the end of it?

Focus on...

Wearables I

Wearing human technology

- we already have some / wear some
  - we have always had textile for our clothes
  - we have had watches around our wrist for centuries
  - we have worn eyeglasses as vision aids for centuries, too
  - we use portable monitors for health care—e.g., Holter ECG monitors

Wearing computing devices

- miniaturisation of technology makes it possible to think of wearing tiny computing devices
  - we can insert electronics in textile—*e-textile*
  - we have Apple Watch, Withings Scan Watch, and the like
  - we have seen Google Glass Explorers
  - we can track our physical activity with FitBits and the like

Example: E-Textiles I

Electronic textiles (e-textiles)

- e-textiles are fabrics enabling the integration of digital components and electronics
- two sorts
  - e-textiles embedding ICT components and devices into garments
  - e-textiles integrating electronics directly into the textile substrates

Example: E-Textiles II

E-textiles for health care

Prosthetics I

Cyborgs [Clynes and Kline, 1960]

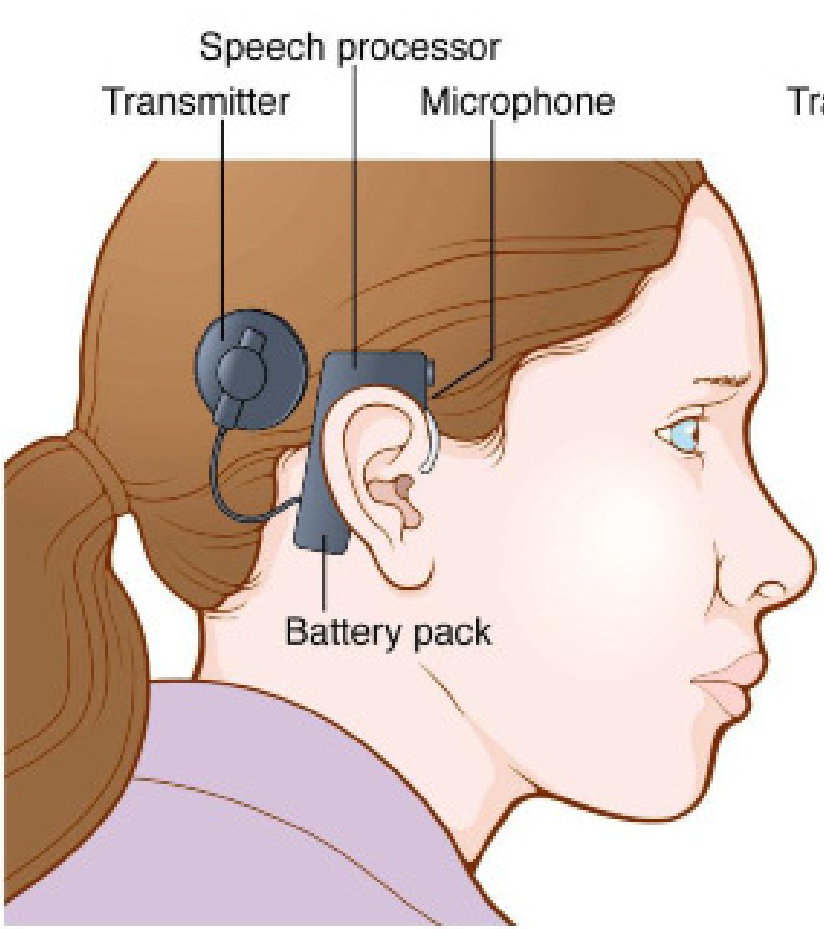
cyborg — short for *cybernetic organism*

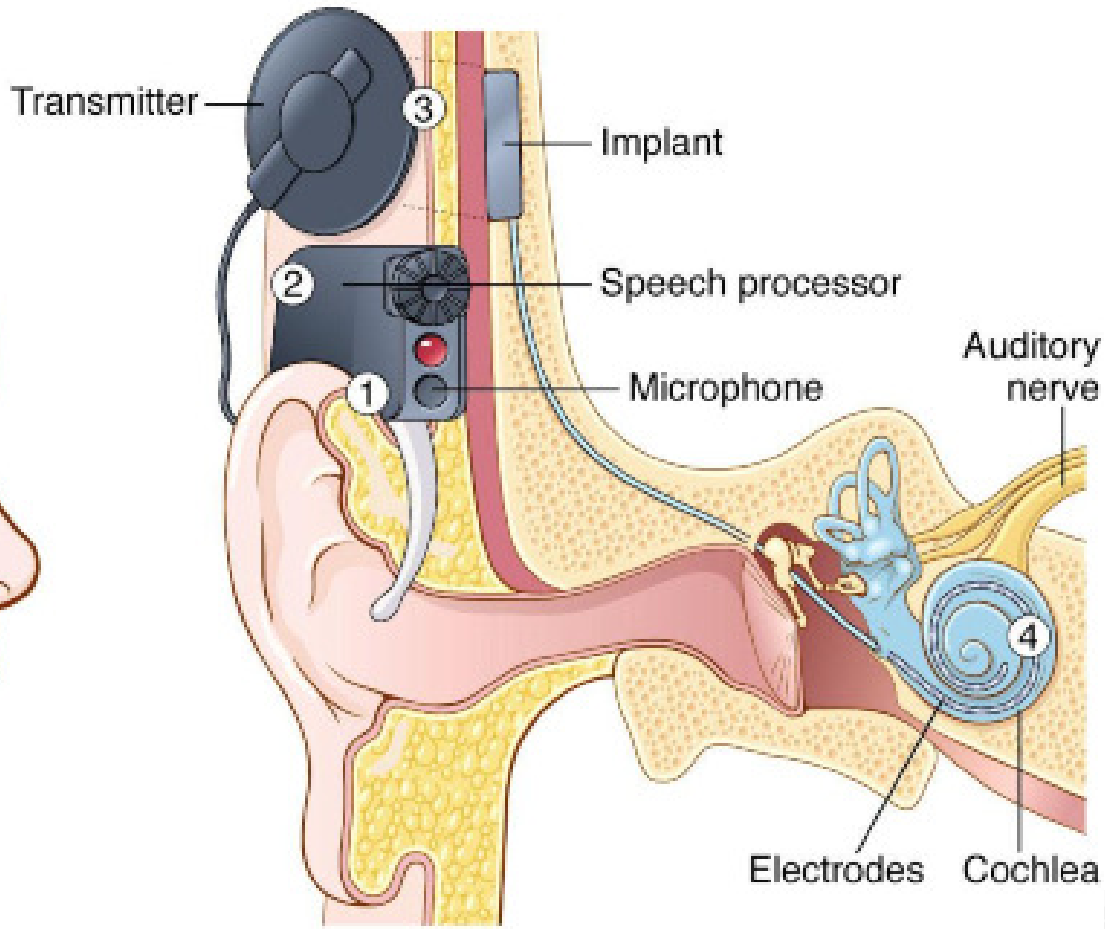
a being with both biological and technological body parts

Cyborgs around us

- some hundred thousands humans already have surgically-implanted *cochlear implants*
  - for acoustically-impaired people
  - first developed in the mid-1960s
  - connect directly to the brain

Prosthetics II





Cochlear implants

Prosthetics III

Prostheses

- "prosthetics amplify our bodies, the power of all of our senses, and the dexterity of our hands "
- a *prosthesis* patches defective humans
- and improves human capabilities over their natural reach
- it is not something that we just wear
- it is something that we *integrate* with our body, and working with it

The Drives: Health and Power I

Self-awareness

- humans are highly *self-aware*
- they understand (some of) their *limitations* and defects
  - including their mortality
- and, they aim at *overcoming* them

Self-empowerment

- humans value their own capabilities
  - both *physical* and *cognitive* abilities
- they depend on them for the evaluation of their own *worth*
  - to feel *safe* and *powerful*
- and, for achieving their own goals
  - e.g., the *invisibility cloak* [Zambonelli and Mamei, 2002]

The Drives: Health and Power II

It's important for technologists to understand this desire to have superhuman powers and extraordinary abilities [Rose, 2014]

Immersive Technologies I

Virtual reality (VR)

- *immersive technologies* allows us to enter virtual worlds
- to perceive and act with virtual environments
  - e.g., haptic gloves, VR headsets, ...
- application scenarios such as *gaming* and *simulation* already exploit immersive technologies on a large scale

Immersive Technologies II

Augmented reality (AR)

- when immersive technologies mix up with spatial applications, humans gain the ability to perceive and act within an *augmented* (physical plus virtual) environment
- where physical actions in the augmented environment have mostly *cognitive empowerment* as a result
  - e.g., car windscreens enhanced with extra information for the drivers

Immersive Technologies III

Industrial application of AR

Immersive Technologies IV

"Diminished" reality

- in a world flooding humans with way too much information, the use of AR technologies might become essential
- to help humans *focussing* on their current necessities
- by filtering most of the irrelevant information out of human perception
  - e.g., car windscreens making highway lanes always look clear and visible to the driver whatever happens around

Fashion

Changing the way we look

- or, the way other people look at us
- this is the goal of *fashion* technology and design
  - for centuries, the most important object of commerce world-wide has been *textiles*
  - the most important (and, costly) materials and technologies, those for *colouring* textiles
- fashion is one of the most powerful human drives
  - one where computational technologies have just started making a dent
  - e.g., (again) *e-textiles*

Early Issues I

Not enough till now

- e.g., batteries too heavy—or, more generally, too little autonomy [Rosslenbroich, 2014]
- typically too intrusive to allow for a natural human interaction
- not easy to be actually "embodied" within everyday human behaviour
- not really "fashionable"

Early Issues II

Google Glass: would we really like to wear that?

Focus on...

Replication of Life

Creating life

- the question "what is life?" has led humans to try and generate new life forms
- humanoids *robots* have populated both sci-fi novels and the engineering labs in the last decades
- not just machines doing things by themselves (*autonomy*), not just *intelligent* machines: it is both about the *body* and the *soul*

Anthropomorphs I

Anthropomorphs (Merriam-Webster)

a stylized human figure (as in prehistoric art)

http://www.merriam-webster.com/dictionary/anthropomorph

Anthropomorphs II

The Mechanical Turk (1770, Wolfgang von Kempelen)

Anthropomorphs III

La Joueuse de tympanon (1784, Peter Kinzing)

Anthropomorphs IV

Human appearance

- we instinctively look for human-like features all around us
  - e.g., seeing human faces over inanimate objects
  - or, finding smiles in animal faces—like, in dolphins
- we know ho to face and solve physical problems with using legs, arms, and hands
- we are accustomed at interacting and working with humans—with human bodies
- also, we typically see humans performing tasks and solving problems by exploiting their own bodies
- so, when human tasks are to be delegated to robots, and humans are around, *humanoid robots* just make sense

Anthropomorphism I

Anthopomorphism (Oxford's Learner)

the practice of treating gods, animals or objects as if they had human qualities

http://www.oxfordlearnersdictionaries.com/definition/english/anthropomorphism

Anthropomorphism II

The intentional stance

- we often explain human activity via statements such as
  - Carlos got rain tires because he believed it was going to rain
  - Charles is working hard because he wants to win his first title
- which can be read in terms of *folk psychology*, by which human behaviour can be explained and *predicted* through the attribution of mental attitudes, such as believing, wanting, hoping, fearing, ...
- the philosopher Daniel Dennett coined the term intentional system to describe entities *'whose behaviour can be predicted by the method of attributing to it belief, desires and rational acumen'* [Dennett, 1971]
- humans are prone to provide an intentional stance to almost anything
  - sacrifices for ingratiating gods benevolence
  - animism
  - ...

Anthropomorphism III

Intentional stance [Dennett, 2007]

The intentional stance is the strategy of interpreting the behavior of an entity (person, animal, artefact, whatever) by treating it as if it were a rational agent who governed its 'choice' of 'action' by a 'consideration' of its 'beliefs' and 'desires.' The scare-quotes around all these terms draw attention to the fact that some of their standard connotations may be set aside in the interests of exploiting their central features: their role in practical reasoning, and hence in the prediction of the behavior of practical reasoners.

Anthropomorphism IV

Ascribing mental qualities to machines [McCarthy, 1979]

Ascribing mental qualities like beliefs, intentions and wants to a machine is sometimes correct if done conservatively and is sometimes necessary to express what is known about its state [...] it is useful when the ascription helps us understand the structure of the machine, its past or future behaviour, or how to repair or improve it

Conversation I

Cognitive process

- *mind reading* is pointed out as an essential in conversations, and more generally in social life
- as the ability to understand motivations, beliefs, goals of the other participants while they speak—*theory of mind* [Wimmer and Perner, 1983]

! some other primates have exhibited some theory of mind [Premack and Woodruff, 1978]

→ the intentional stance is basically a *requirement* for any *conversation with a machine* of any sort

Conversation II

Conversation uses face and body [Nishida et al., 2014]

- according to joint activity theory [Clark, 1996], the basic setting for language use is face-to-face conversation
- in a conversation, the speaker usually coordinates multiple parts of his/her body, including his or her eyes, face, hands, head, and torso
- the speaker does this to express what he/she wants to communicate
  - e.g., pointing to refer to a portion of the surrounding environment
- complementing or even substituting utterance
- integrating all the diverse forms of communication allow humans to make sense out of a conversation

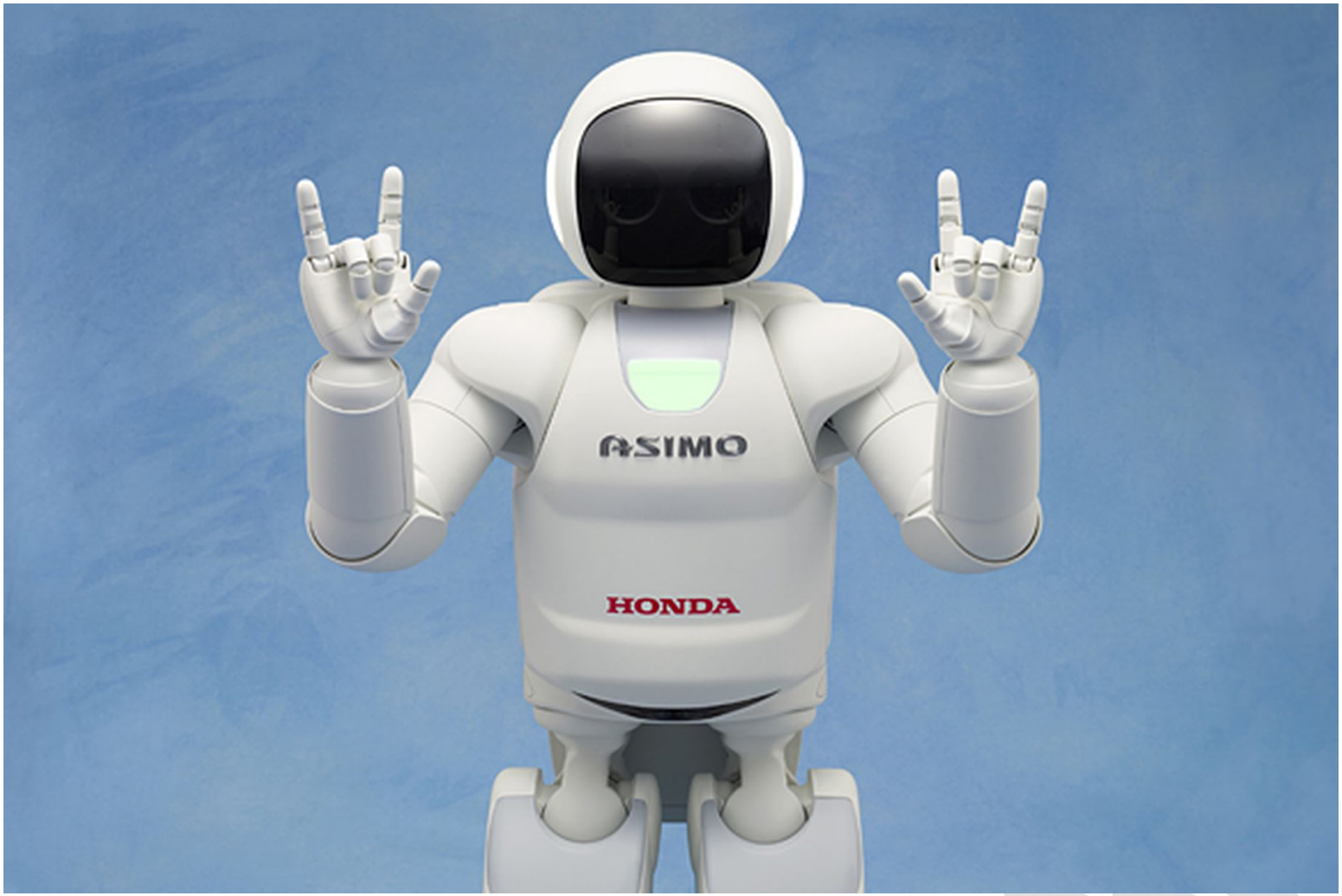
→ machines should be expected to use their humanoid body – or, some part of it, e.g., their face – to naturally interact with humans

The Drive: Animism I

Machines with human(-like) soul and body

- delegating activities to humanoids robots might make sense
  - full human conversation, with body talk and mind reading
  - allowing for social interaction between humans and robots

The Drive: Animism II



From Asimo... (2010, Honda)

The Drive: Animism III

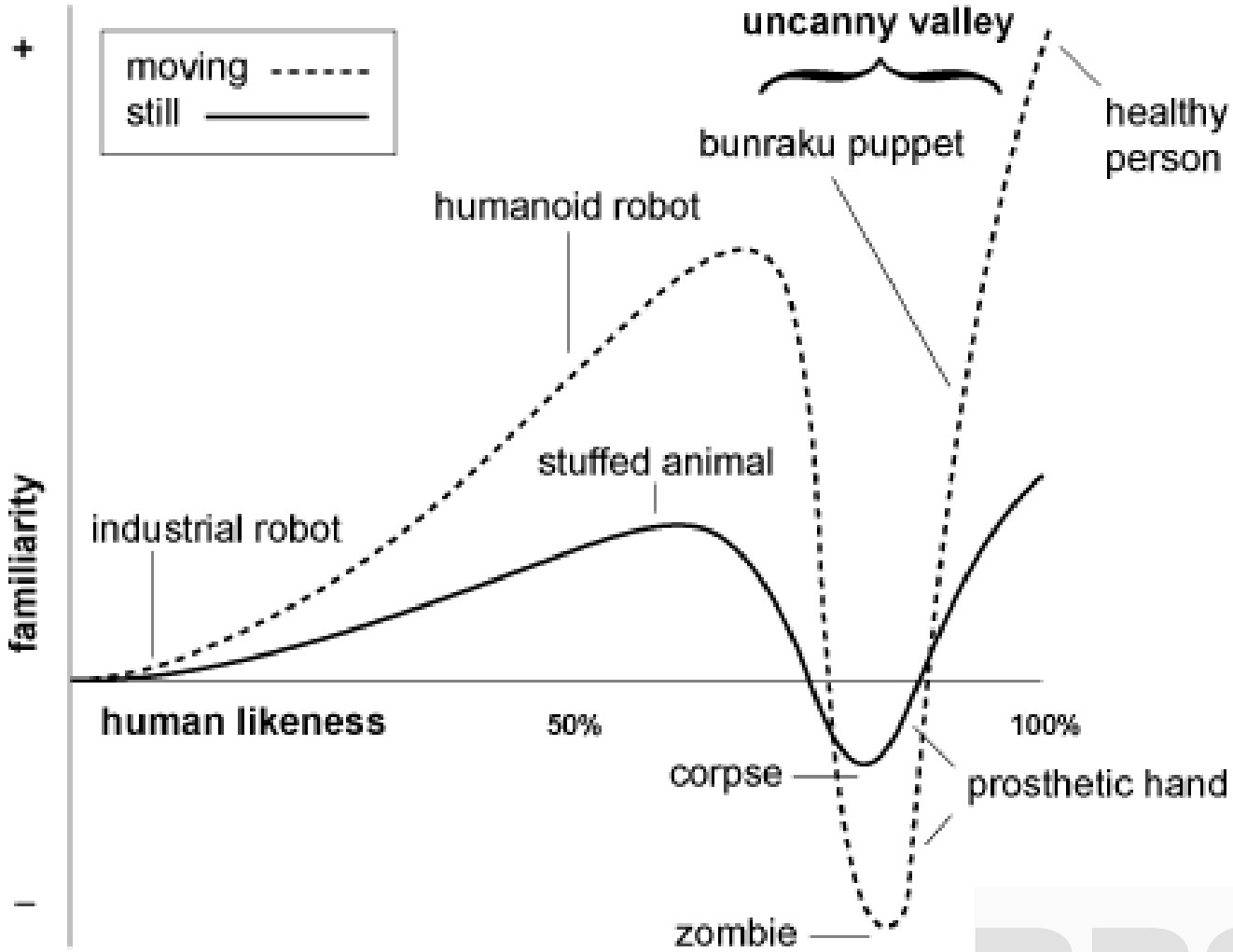
. . . to 3E – A18 (2018, Honda)

The Drive: Animism IV

Issues

- yet, it might be turn out as creepy, when
  - body expression is imperfect, since we are very sensitive to even minor nuances
  - when perceived verbal and physical expressions and apparent intentions are *not* visibly *aligned*

The Drive: Animism V



The Uncanny Valley (1970, Masahiro Mori)

Focus on...

Enchanted Objects [Rose, 2014] I

Magic objects in human fairy tales and oral tradition

- the *wishing wand* or *ring* that fulfils any desire in an instant
- the *flying carpet* that swiftly transports us
- the *bottomless purse* that never runs out of money
- the *superspyglass* through which we can see thousands of miles
- *magic boots* that enable us to walk miles in one stride
- the *horn* or whistle with which we can summon help
- the *crystal ball* that enables us to know the future
- the *invisibility cloak* or shield that hides us from danger
- the *endless table* that feeds hundreds with a bountiful feast

Enchanted Objects [Rose, 2014] II

Do we have them already somehow?

- do we have something like superspyglass?
  - remote cameras?
- do we have something like a crystal ball?
  - meteo app?

! working like that, maybe—not really the objects

When the Ordinary Thing Becomes Extraordinary I

Augmenting ordinary objects

- "Enchanted objects start as ordinary things—a pen, a wallet, a shoe, a lightbulb, a table. The ordinary thing is then augmented and enhanced through the use of emerging technologies . . . so that it becomes extraordinary" [Rose, 2014]
- the so-called *emerging technologies* define the technical basis for the Internet of Things

When the Ordinary Thing Becomes Extraordinary II

As the ordinary thing becomes extraordinary, it evokes an emotional response from you and enhances your life.

[Rose, 2014]

How to Make the Ordinary Thing Extraordinary I

Technologies for augmenting ordinary objects

- sensors
- actuators
- wireless connection
- embedded processing

How to Make the Ordinary Thing Extraordinary II

Environment

- sensors — to perceive the world around the object
- actuators — to change the world around the object

Computing

- embedded processing — to compute and elaborate data in order to determine the behaviour of the object

Connection

- wireless connection — to interact with other objects to exchange information

Why Ordinary Objects? I

Every day objects. . .

- already have a place in our *everyday life*
- we have *habits* when using them
- their *function* addresses well-known human needs
- they have a social *history of use*, which has refined their *design* – shape, colour, material, . . . – over the years, to adapt to our usage

→ no need to invent new needs for them to be useful

→ no price of novelty to pay

→ *familiarity* in the design (by engineers), *selection* and *usage* (by users)

Why Ordinary Objects? II

Moleskine Pen+

Why Ordinary Objects? III

Example: Moleskine Smart Writing System

- a *pen*
- *enhanced* with
  - battery for autonomy
  - sensors to detect position and motion
  - processor and memory to extract, elaborate, and record data
  - (wireless) connectors to re-charge and exchange data
- which can be used *exactly as a pen*
- yet, it allows digitalisation of handwriting and drawing, and whatever follows from there

Ordinary Objects, How?

Macro-trends

- miniaturisation
- embeddedness
- *cost*

Cost

- the cost of processors, connectors, sensors, actuators, . . . , decreases in a nonlinear way
- e.g., because the cost of computation goes down while speed goes up at the same time
- as a result, "We can embed silicon and sensors in any object—shoes, pill bottles, lightbulbs, wallets, and furniture—virtually without noticing the incremental costs." [Rose, 2014]

Next in Line...

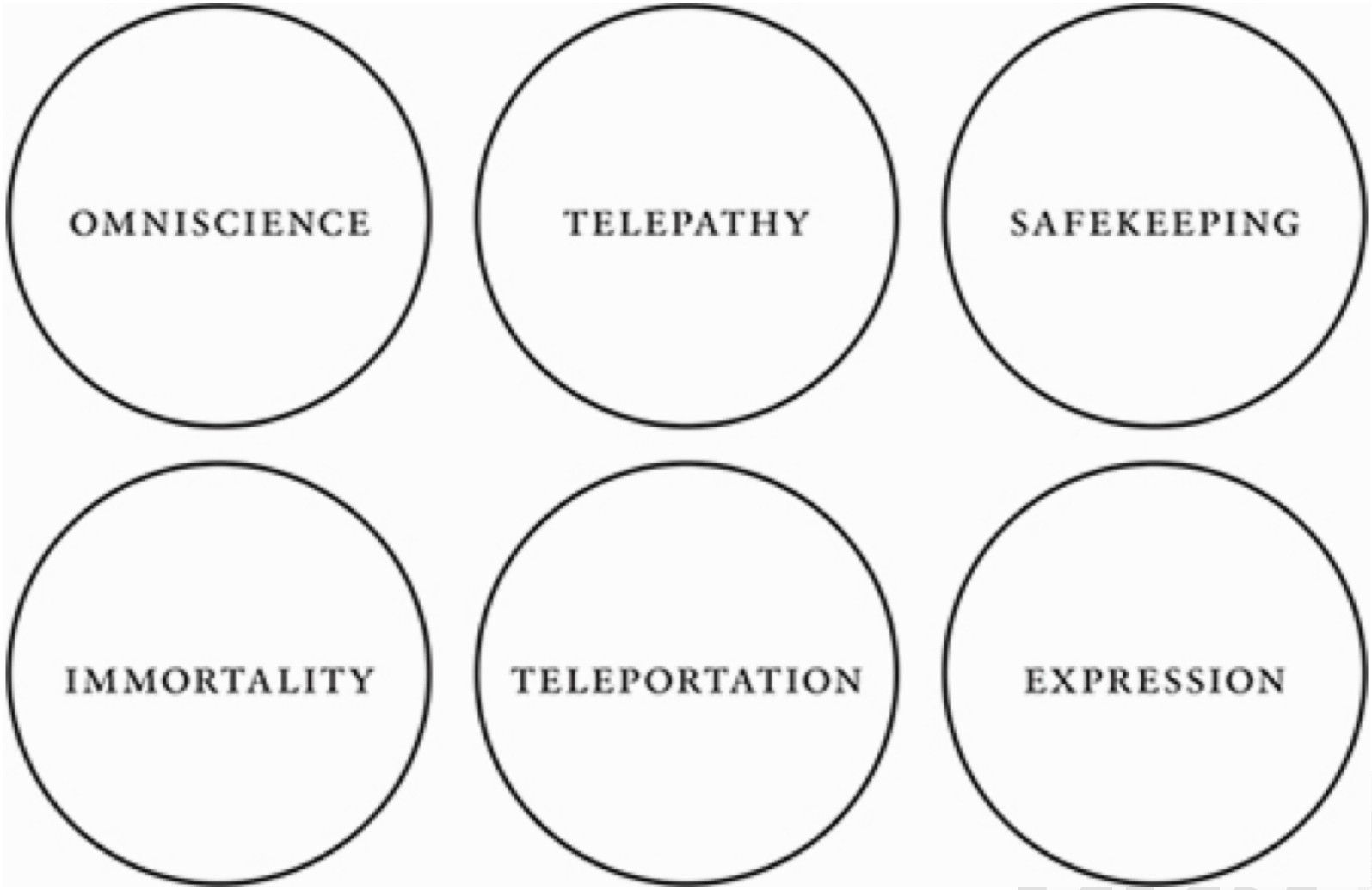
Storytelling

Design vs. storytelling

- objects have a *history of usage* by humans
- objects have a place in our culture
- as witnessed by folklore and literature
- which typically provide a synthetic view of our most basic *psychological needs*

There is a persistent interplay between *fiction* and *invention*—mythology, fairy tales, fantasy, science fiction

Psychological Drives I



Six psychological drives for humans [Rose, 2014]

Psychological Drives II

Omniscience [Rose, 2014]

This is the desire to have great knowledge. We have a voracious appetite to know as much as possible and to know about things that go beyond facts and information. We would love to be able to predict what will happen in the future.

Telepathy [Rose, 2014]

We have a powerful desire to connect to the thoughts and feelings of others, and to be able to communicate with ease, richness, and transparency. We want to know others and to feel known by them.

Safekeeping [Rose, 2014]

We fervently wish to be protected from harm. To feel comfortable, safe, and at ease.

Psychological Drives III

Immortality [Rose, 2014]

We want to be healthy, strong, fully capable. We dream of living long lives, vital to the last moment.

Teleportation [Rose, 2014]

We crave movement, to be transported easily and swiftly and joyfully from one place to another, and to live unconstrained by physical limits or boundaries.

Expression [Rose, 2014]

We all wish to be generative, to fully express ourselves in many forms and media—acting, music making, art, writing, cooking, dancing, documenting our lives.

Omniscience

Examples

- Philip Pullman's Alethiometer ("His Dark Materials Trilogy")
- "I Ching" (Chinese divination text)
- barometers

Telepathy

Examples

- *mind reading* is one of our essential communication skill
- we constantly try to understand what other are thinking, which intentions they have, what they are not telling us, ...
- Marvel X-Men Cerebro
- Turing "Bombe" against Nazi's "Enigma"
- tell-all culture by social media
- our smartphones telling us how to go there—with no communication about "there" from us

Safekeeping, Immortality, Teleportation, Expression

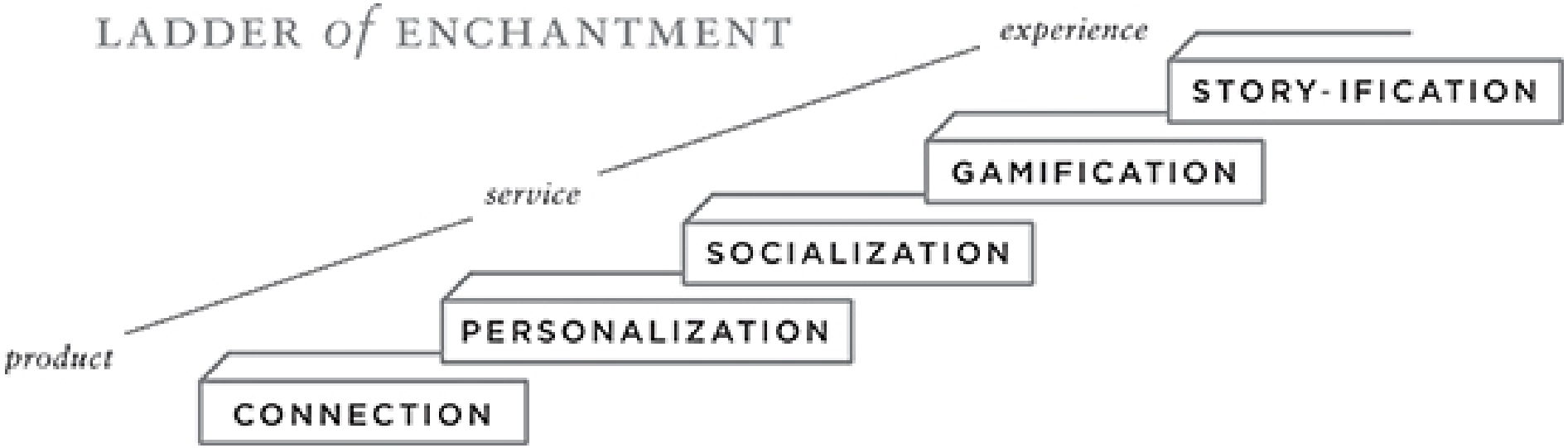
And so on, and so forth

The pattern is the same: you may easily add your own examples here

Next in Line...

How do We Invent / Design Enchanted Objects? I

Five steps on the ladder of enchantment [Rose, 2014]



How do We Invent / Design Enchanted Objects? II

connection — adding sensing/sensor capabilities by connecting to the cloud

personalisation — adding and leveraging personal information

socialisation — adding connections to friends, loved ones, and colleagues

gamification — adding the fun and motivational elements of video games

story-ification — adding a human narrative for the product, service, or user

Do we really need that?

Or, maybe this is too much further. Or, not enough. Or, too vague. Actually, who cares.

The Point

- there are several different futures that *technology drives* open for us
- there are diverse *human drives* that shape the space of our deep needs
- enhanced everyday objects – or, *enchanted objects* – is one sure place where technology and human drive meet
- as far as we, as *human users*, are concerned

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I. Humans

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