Why Digital Twins Need to Take Complexity Science on Board
How Difficult Is It to Create Digital Twins?

Deep Fakes suggest a realism that is not really there!
CHRIS ANDERSON’S DREAM:

The end of theory: the data deluge makes the scientific method obsolete.

Wired Magazine 16(7), 2008
Complex Dynamical Systems: Limits to Predictability
Obstacles to Creating Digital Twins

- biases
- randomness
- turbulence
- “butterfly effect” of chaos theory
- uncertainty principle of quantum mechanics
- undecidability theorem of Gödel
- bad convergence of learning algorithms (sometimes)
- overfitting…

Less data or noisy data can sometimes be better!

https://www.kaggle.com/shadabhusain/avoid-overfitting
Many social systems are so complex, that the relevant variables and parameters involved are hard to identify and to measure. **Calibration** of a model with many parameters is often a big problem, and it could get many parameters wrong. **Validation** may be even less possible.

George Box: “All models are wrong. (But some are useful.)”

Josh Epstein: “If you didn’t grow it, you didn’t explain it.”
Exponential vs. Factorial Growth – Implications for the Governance of Complex Systems

- **Data volume**
- **Processing power**
- **Systemic complexity**

- X doubles every 18 months
- X doubles every 12 months
- X grows as a factorial with the number of years

Big Data:
- Evidence-based decision-making
- Not enough data to take good decisions
- Loss of top-down control: Distributed control
- Problem of “dark data”, which can never be processed!

**Years**

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**X**
The Problem of False Positives: Classification Errors Will Happen

Pseudo-objectivity is a serious problem

Overestimation

The more you measure, the worse the result could get!

Measured vs. actual proportion of Infected
Limits to Control
Self-Organization of Pedestrian Flows: Efficient and Adaptive Lane Formation

At low densities:
self-organized lane formation,
like Adam Smith’s invisible hand
Overcoming Congestion by Real-Time Feedback Based on „Mechanism Design“
Decentralized Concept of Self-Organized Traffic Light Control (Self-Control)

Inspiration: Self-organized oscillations at bottlenecks

Optimal compromise between coordination and local flexibility

Published in JSTAT (2008)
Decentralized Can Outsmart Centralized Control

Public transport

Motorized traffic

Pedestrians and Cyclists

<table>
<thead>
<tr>
<th>Category</th>
<th>Public transport</th>
<th>Motorized traffic</th>
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<td>63.9 vh</td>
<td>59 s</td>
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<td>-9%</td>
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<td>Average red times</td>
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How to Turn Supply Chains...
... Into A Circular Economy?
We Can Learn From Nature!
<table>
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<th>Design for Values/Value-Sensitive Design</th>
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<tr>
<td>• Privacy</td>
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<td>• Self-determination</td>
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<td>• Flexibility</td>
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Goals must be balanced (politically negotiated). Otherwise, the approach is oversimplified, inadequate.
Design for Democracy

- Human rights, human dignity
- Freedom
- Self-determination
- Pluralism
- Protection of minorities
- Division of power
- Checks and Balances
- Participation
- Transparency
- Fairness
- Justice
- Legitimacy
- Anonymous, equal votes

- Privacy
- Protection from misuse/exposure
- Right to be left alone
As compared to a war room setting, a “peace room” is characterized by a number of additional features such as: a higher degree of transparency (to reduce possible flaws and increase trust), a democratic framework of operation (for legitimacy), the use by interdisciplinary teams meeting international scientific standards (to achieve the integration of the best knowledge available), the supervision by ethical experts (to ensure responsible use and innovation), a multi-stakeholder and multi-perspective approach (to find solutions that work for everyone – as much as this is possible), and, in order to increase problem solving capacity, participatory opportunities for civil society (by means of NGOs, citizen science, and/or crowd sourcing).
Informational Self-Determination

1. Send (a copy of) all personal data to a personal data mailbox
2. Require legally that personal data can only be used with the informed consent of individuals
3. Create a public platform that allows individuals to determine who is allowed to use what kind of data for what period of time and purpose (and what amount of money)
4. Build AI-based digital assistants that help people to easily administer personal data according to their preferences
5. Allow governments and scientists to run statistics on data
6. Report data use transparently to data mailbox
Build digital democracy

Open sharing of data that are collected with smart devices would empower citizens and create jobs, say Dirk Helbing and Evangelos Pournaras.
'Digital transformation' sounds harmless, given that the explosion in data volumes, processing power and Artificial Intelligence has driven humanity and the entire world to a point of no return. We will surely see a new civilization, but we are at a crossroads. The future needs to be re-invented, decisions must be taken.

After the automation of factories and the creation of self-driving cars, the automation of society is on its way. But there are two kinds of automation: a centralized top-down control of the world and a distributed control approach, supporting local self-organization. Using the power of today's information systems, governments and big tech companies seem to engage in the first approach. Might they even build a 'digital Crystal Ball' that knows almost everything, including your personality, and a superintelligent 'digital God' to control what we do?

We are much closer to such 'science fiction scenarios' than you probably think. In this much expanded second edition of The Automation of Society is Next: How to Survive the Digital Revolution (2015), the author discusses lessons learned on digital democracy, aspects of transhumanism and far-reaching thoughts about life in the digital age and what it may mean to be human in the future.