



A Digital Twin approach to Precision Livestock Farming

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The benefits of **Digital Twins**:

- Based on data-driven modelling
- For Precision Livestock Farming

But you might ask:

- How do I make my cow digital?
- Is Machine learning magic?

Precision Livestock Farming

The goal:

- Improve the efficiency of production
 - I.e. Targeted resource use, fertility, etc.
- Increase animal and human welfare

How:

- Information and communication technologies (ICT) + Software
- Increasingly: Artificial intelligence!

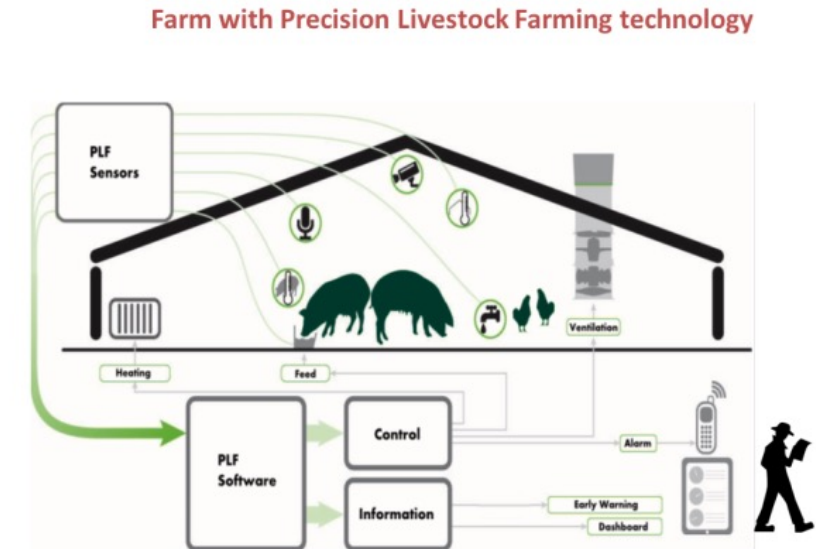


Fig 1: Guarino, Marcella et al. "A blueprint for developing and applying precision livestock farming tools: A key output of the EU-PLF project." *Animal Frontiers* 7 (2017): 12-17.

Artificial intelligence

- An automatic method to learn from data
- Requires **sufficient** data
- Increasingly automates manual task

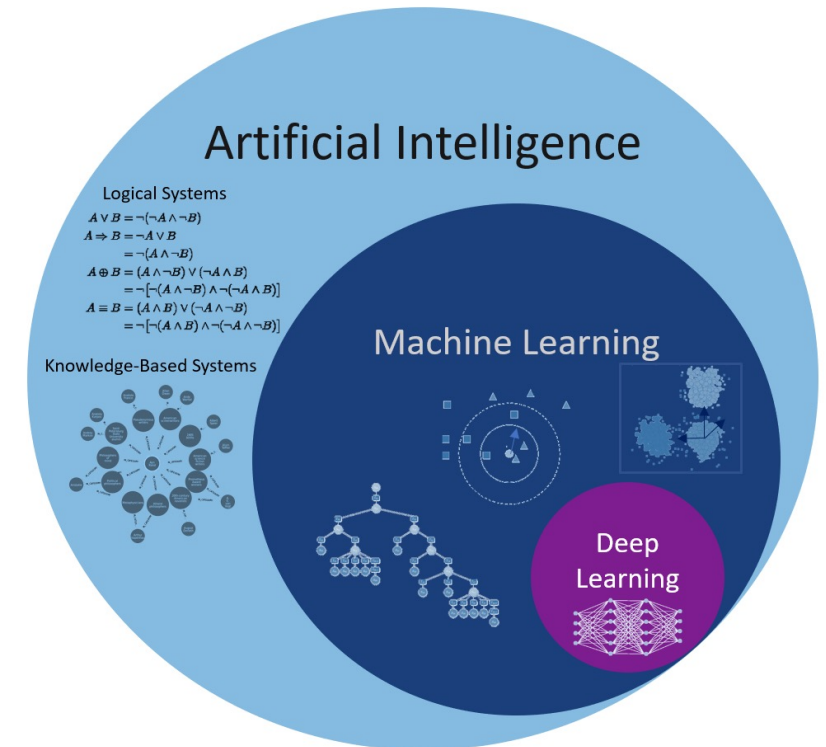


Fig1: <https://data-science-blog.com/blog/2018/05/14/machine-learning-vs-deep-learning-wo-liegt-der-unterschied/>

Recap



A move to data:

- Mechanistic → Machine learning → Deep learning

Increased animal data can help improve management...

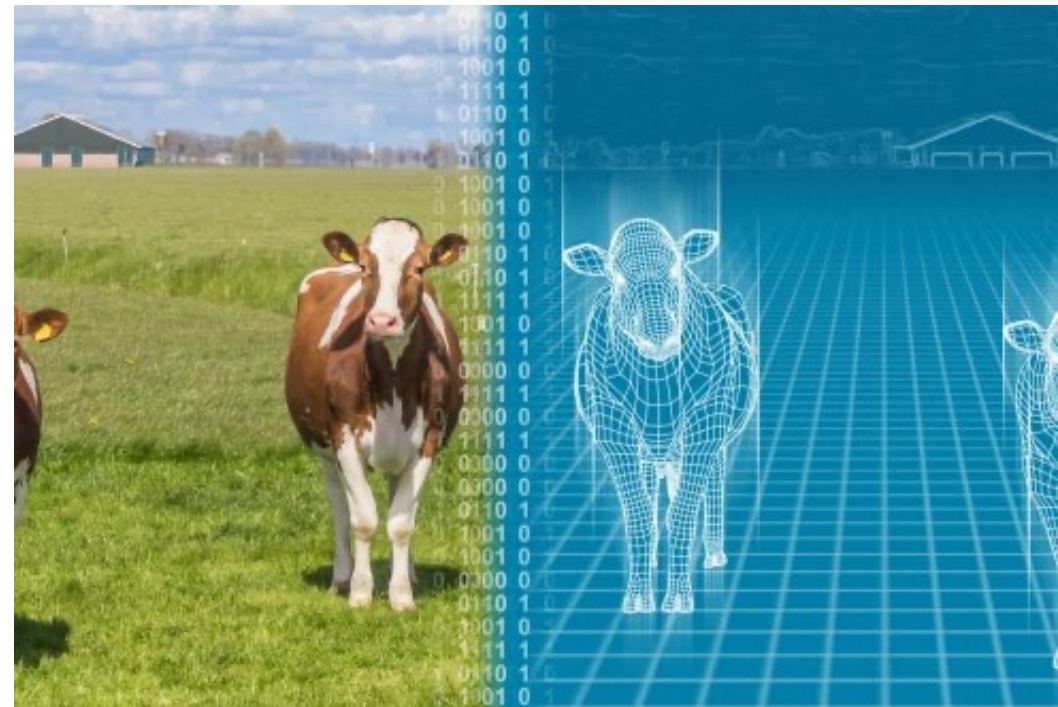
...But how can we apply this?

The Digital Twin

What is the Digital Twin?



What is the Digital Twin?

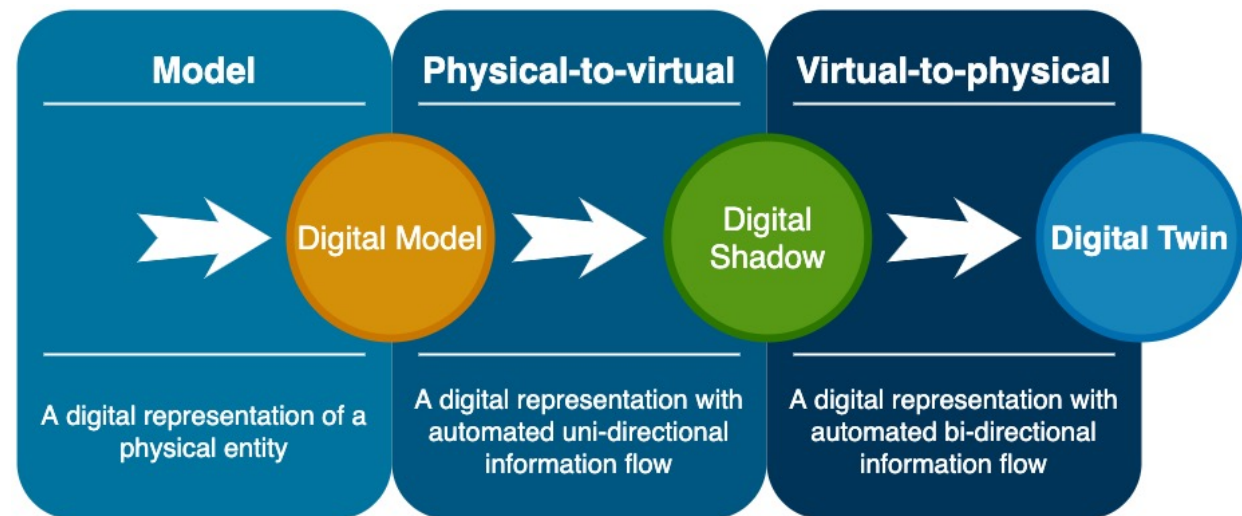


Digital Twin: Definition

“A real-time synchronized virtual representation of a product, process or environment... Across it’s **life-cycle**” [1, 2].

A novel means to achieve [3] :

- **Digitization**
- Using high-fidelity **modelling**
- and **simulation**



[1] D. Jones, C. Snider, A. Nassehi, J. Yon, B. Hicks, Character-ising the digital twin:A systematic literature review 29 36–52.doi:10.1016/j.cirpj.2020.02.002.; [2] M. Grieves, Digital twin: Manufacturing excellence through virtual fac-tory replication.

[3] L. Wright, S. Davidson, How to tell the difference between a model anda digital twin 7 (1) 13.doi:10.1186/s40323-020-00147-4

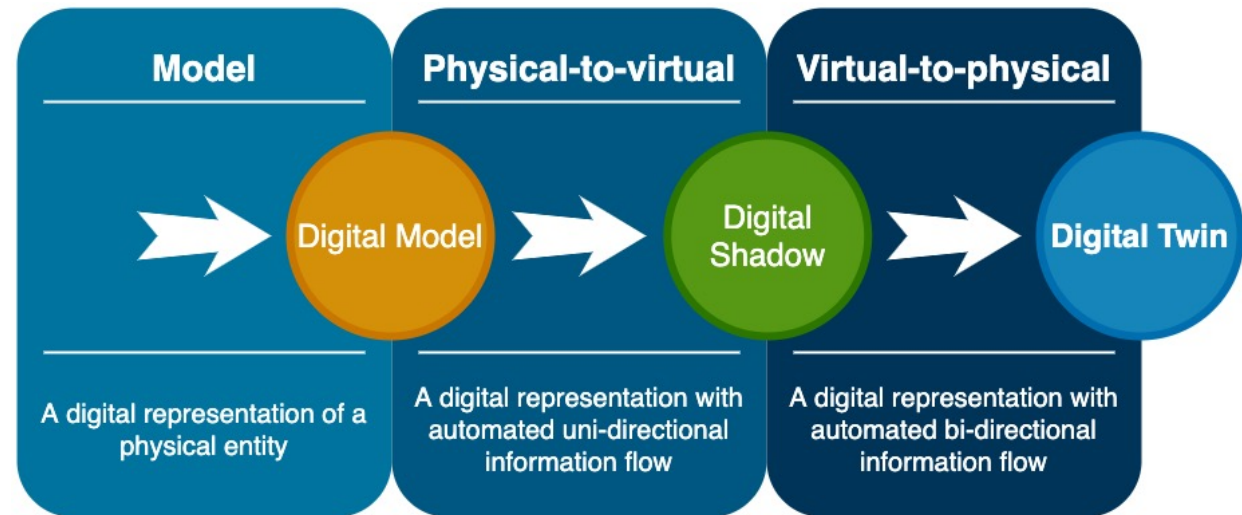
Digital Twin: Definition 2

Is this a technology?

→ Yes and No

What is it then?

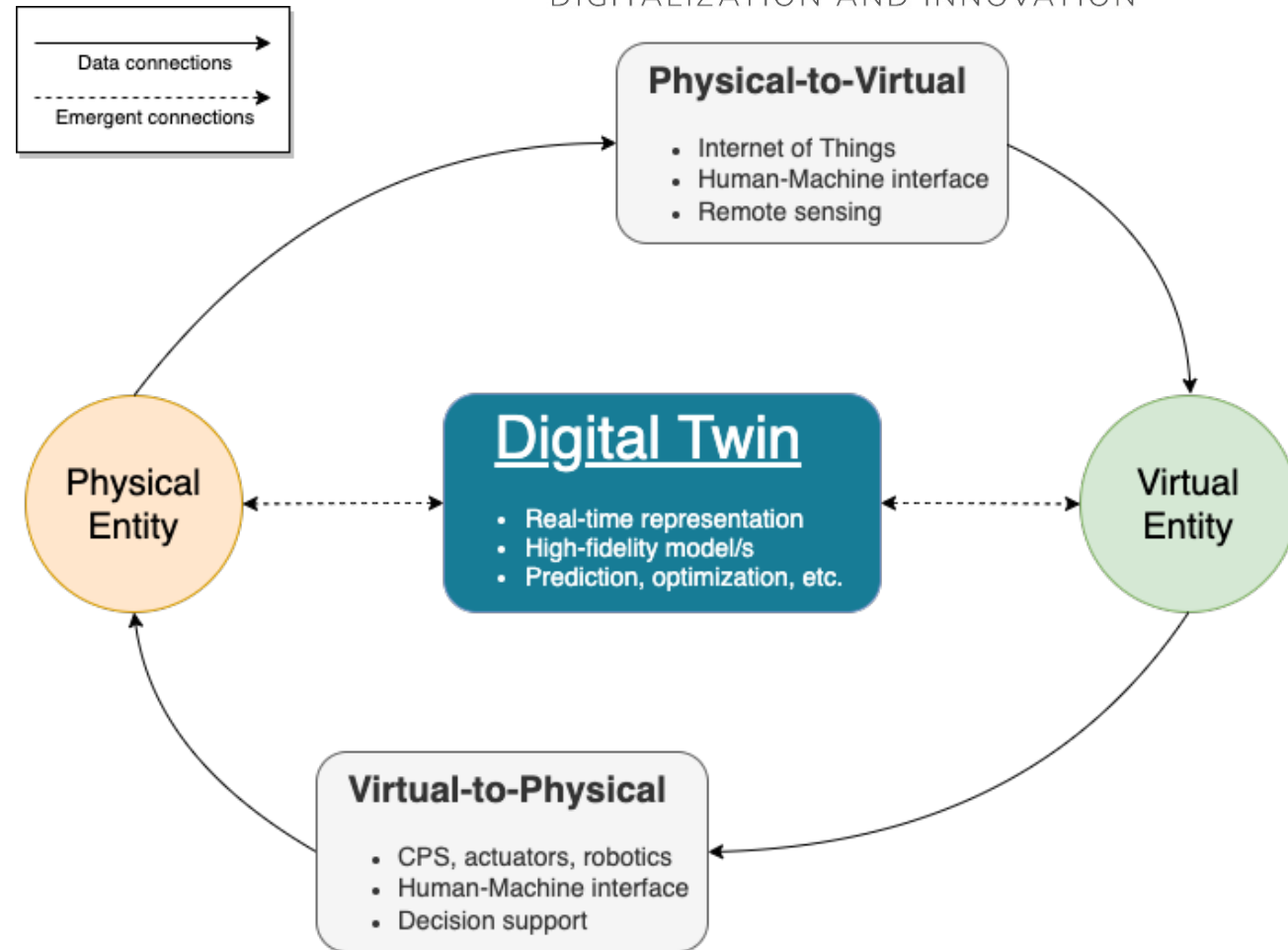
→ Conceptual framework



Digital Twin: Conceptualization

Automation lifecycle:

Observation → Physical-to-Virtual
Interpretation* --> Model
Prediction --> Simulation
Action → Virtual-to-Physical



* Dependent on use-case

Digital Twin: Applications

Manufacturing:

- Original and most developed area

Smart cities:

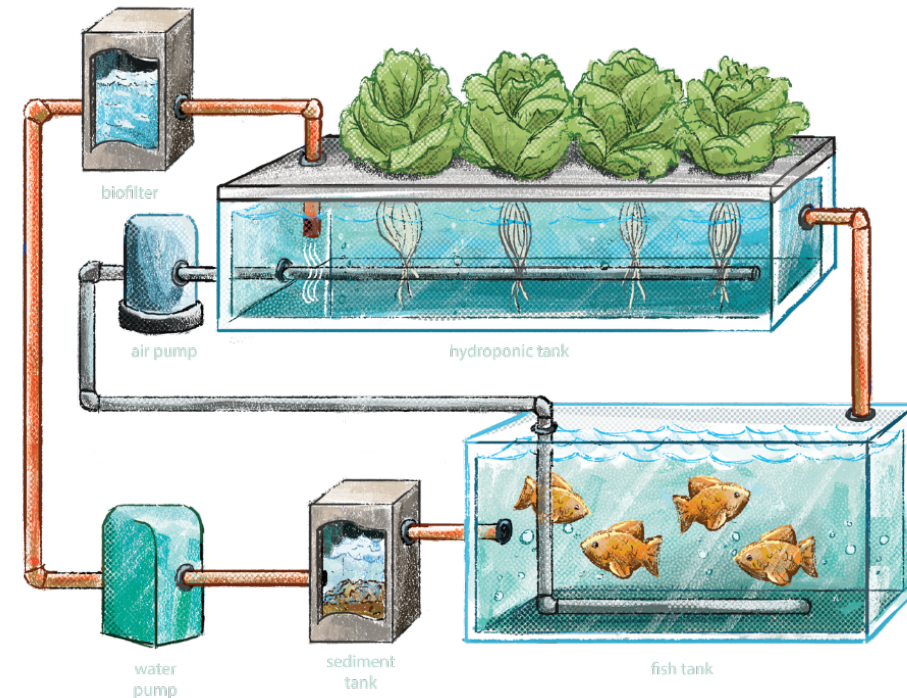
- Complex interconnected systems

Medicine:

- Biological systems

Agriculture:

- Aquaponics, controlled climates environments, building design, **PLF**.



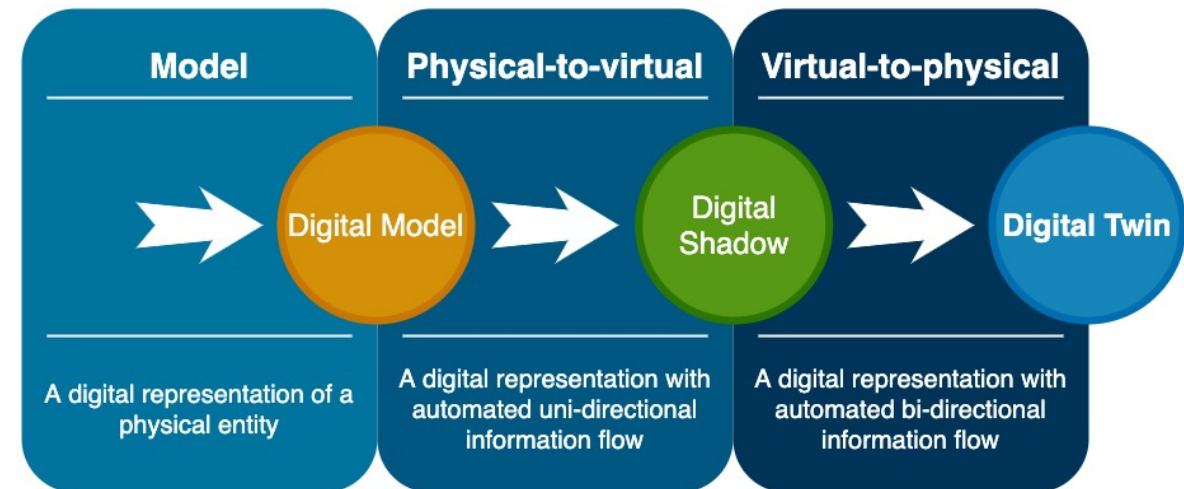
Digital Cow?

How to make a Digital Twin of a Cow:

- A real-time representation of a Cow
- Multiple data sources
- Monitoring across the life-cycle
- One or many models

Automation loop:

- Realtime monitoring
- Decision support
- Targeted feeding



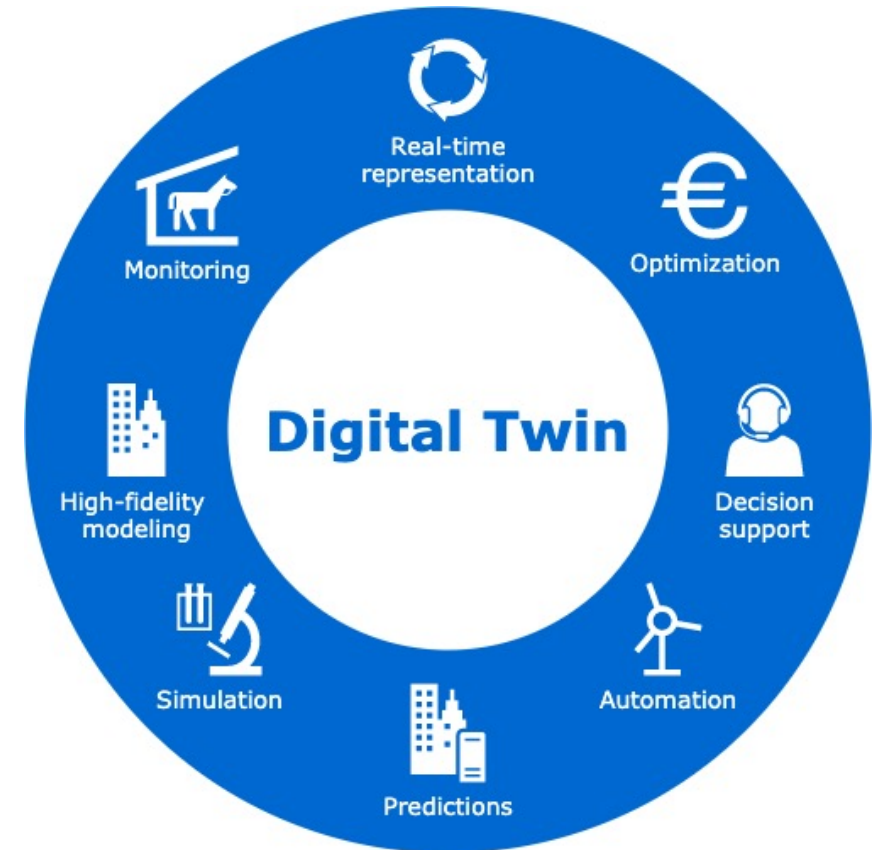
Digital Cow: Benefits

Now:

- Real-time monitoring
- Consolidated view I.e. data sources and models
- Feedback → Automation and decision support
- Simulation → Prediction and optimisation

Future:

- Full farm mentoring
- Sustainability
- Traceability



Digital Cow: Benefits 2

- Cross domain research
- Realistic system modelling



- Individual Digital Twins
- Optimization

Image left: <https://www.josephinum.at/en/forschung-und-pruefung/agrartechnik/kompetenzen-agrartechnik/duengung-pflanzenschutz.html>
Image right: <https://www.alltech.com/en-ie/blog/guide-great-grazing>

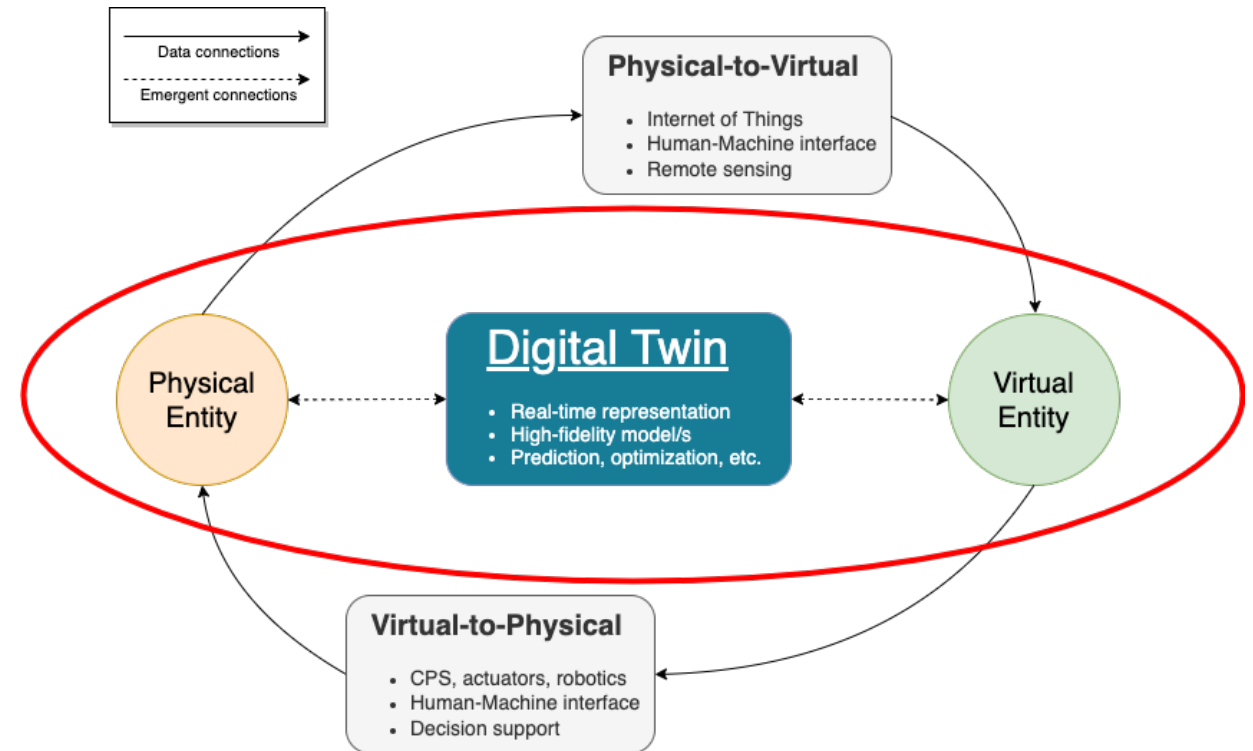
Digital Cow: Challenges

Animal models:

- Complex biological systems
- Behaviour is complex to model

Requires more data:

- Expensive
- Time consuming



Summary

- Data, data, data, data!
- Digital Twins provide a framework to:
 - Understand dynamic systems
 - Model real-world Entities
 - Mirror them in real-time across their entire life
 - Provide a feedback loop

Thank you for your attention!

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