AUTOFARM™

Inspired by life, for life.

Beyond the Digital Twin

A Causal Approach for Agriculture

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Beyond the Digital Twin: A Causal Approach for Agriculture

Why the digital twin is not suited for operational agriculture, and why a physical-invariant approach is superior

1. Structural limitations of digital twins in living systems

Recent work on digital twins in agriculture converges on a shared conclusion: results are mixed.
This is not an implementation issue but a **structural limitation**.

Living systems are:

- non-linear,
- sensitive to micro-variations,
- highly context-dependent,
- impossible to fully parameterize,
- impossible to measure continuously.

Yet a digital twin must:

- simulate,
- calibrate,
- predict,
- integrate thousands of variables,
- operate in real time.

Living systems cannot truly be simulated — **they must be understood**.

2. An infrastructure too heavy for a low-margin sector

To function properly, an agricultural digital twin requires:

- permanent connectivity,
- massive data pipelines,
- cloud storage,
- complex models,
- continuous maintenance,
- rare technical expertise.

This architecture is **costly, fragile, and fundamentally non-scalable** at global level.
It does not match the realities of farms, rural infrastructure, or agricultural economics.

Digital twins will therefore remain useful for:

- research,
- academia,
- theoretical simulations,
- controlled environments.

But they will **never** become an operational agricultural standard.
It is structurally impossible.

3. A robust alternative: physical invariants of the crop cycle

A more resilient approach focuses on the **physical invariants** that structure every crop:

- soil (structure, texture, fertility, tillage),
- water (availability, dynamics, hydric stress),
- climate (temperature, radiation, wind, humidity),
- crop structure (density, planting, practices).

These invariants are:

- measurable,
- explainable,
- reproducible,
- universal.

For greater precision, they are segmented into **growth stages**, enabling a causal reading of the crop cycle.

4. An ultra-compact digital format (~10,000 characters)

A full crop cycle can be represented in a **digital file of about 10,000 characters** — extremely compact.

This file is:

- lightweight,
- causal,
- explainable,
- reproducible,

- universal,
- cloud-independent,
- compatible with edge devices (sensors, robots, local stations).

It requires no permanent connectivity — only occasional synchronization with sensors and robots, which is already necessary for autonomous farming.

5. Operational functioning: a causal and universal diagnostic

At the end of the cycle, a **single file** is generated.
It contains the physical invariants and the growth stages.

This file makes it possible to:

- understand why two identical plots (soil, climate, variety) produce different yields,
- identify the physical constraints that limited growth,
- adjust practices on similar plots for the next cycle,
- create shared intelligence across plots, farms, and regions.

It is a **causal, reproducible, universal** diagnostic.

6. Why this approach can become a global standard

If agronomically validated, this format offers decisive advantages:

- lean: extremely low resource consumption,
- effective: captures the real causes of yield variation,
- simple: easy to operate, audit, and transmit,
- scalable: applicable in all countries, even without connectivity,
- institutionally robust: explainable, standardizable, compatible with insurers and banks,
- industrially compatible: DJI, METOS, Ecorobotix, Microsoft.

It delivers results as useful as a digital twin, but with an architecture **100× simpler, more frugal, and more universal**.

7. Conclusion: a conceptual rupture, not a variation

This approach does not attempt to simulate life.
It seeks to **describe its invariants**.

It does not reconstruct a system.

It **encodes what matters**.

It does not predict.
It **diagnoses**.

It is a conceptual, methodological, and industrial rupture.
And if validated by Agroscope through Innosuisse, it can become the **global protocol** for causal understanding of crop cycles.

Project Ownership

Owner & Founder: Jan Affolter — jan.affolter@autofarm.global

Intellectual Property Holder: Jan Affolter ITS (CHE-104.801.264)

Location: Lausanne, Switzerland

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