Heeft de Agri&Food sector nog toekomst zonder kunstmatige intelligentie in dit tijdperk van big data, sensors en agribots?

AgroConnect-winterwebinar, 25 november 2021

Jakob de Vlieg
Prof. Applied Data Science
Chair AgriFoodTech@TU/e
Lead AgriFoodNature@JADS

JADS Jheronimus Academy of Data Science

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Agenda

- Impact of Big Data & A.I. on Agri&Food sector
- Some ongoing project examples & worldwide initiatives
- Data & A.I. may lead to innovative data-driven business models
- Creative data talent & team science required

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Introducing Jakob de Vlieg

Education

- Chemistry, Univ. of Groningen
- PhD in computer science to analyze biomolecular systems (molecular dynamics)

Career

- EMBL Heidelberg: structural bioinformatics
- Unilever: Head of Biophysics; Head Food Informatics

- Organon BioSciences: VP Molecular Design & Informatics & Head R&D IT
- Radboud Univ-Medical Center.: professor Computational Chemistry (part time)

- Schering Plough/MSD: Global Head Comp. Drug Design
- CEO/CSO Netherlands eScience Center Amsterdam

- Bayer: VP Computational Life Science
- TU/e: Prof . Applied Data Science; Lead AgFoodTech@TU/e; AgFood&Nature@JADS

A global challenge to meet future food supply

Photo by Fang Chen of
Beijing Genomics Institute

Reasons, e.g.
Expanding world population; ca. 9 billion in 2050

Shortage of agricultural land, water and energy

Climate change

At the same time:
We need to increase food production by 70% in 2050!

Currently > 30% of all food produced is wasted

Ambition JADS & TU/e
Provide basic science, engineering & data solutions to produce sufficient food in a sustainable and secure way

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Time is ripe for cross-overs between AgriFood and HighTech

Many ongoing AgriFoodTech projects@ TU/e & JADS

- Precision farming: A.I. and control systems
- Energy solutions for small agricultural equipment

- Stimuli-responsive materials for greenhouses
- Plasma technology to replace chemical pesticides
- Mild food processing & soft matter
- FarmIT; AgriFood DataLab
- 3D Food printing

- Computer vision & data for animal breeding & animal welfare
- From source to consumer: the smart pork chain
- Data sciences & AI for vertical farming

…and many more…

- Consumer acceptance for sustainable food products
- Dynamic Pricing Strategies to reduce food-waste by data

JADS to drive sustainable food production: *AgriFood&Nature line*

- Impact-driven research projects in Agri&Food
- Bridge Research, Valorization and Education
- Educate new data talent:
  - JADS master student course (minor)"*Data-driven Food value Chain*"
  - Master & PDEng student graduation projects (*with companies & institutes)*
  - Fundamental research projects (PhD, etc, funded by NWO, TKI, OPZuid, EC)


JADS Marienburg Den Bosch

Province NB, City Den Bosch, Tilburg Univ, TU/e

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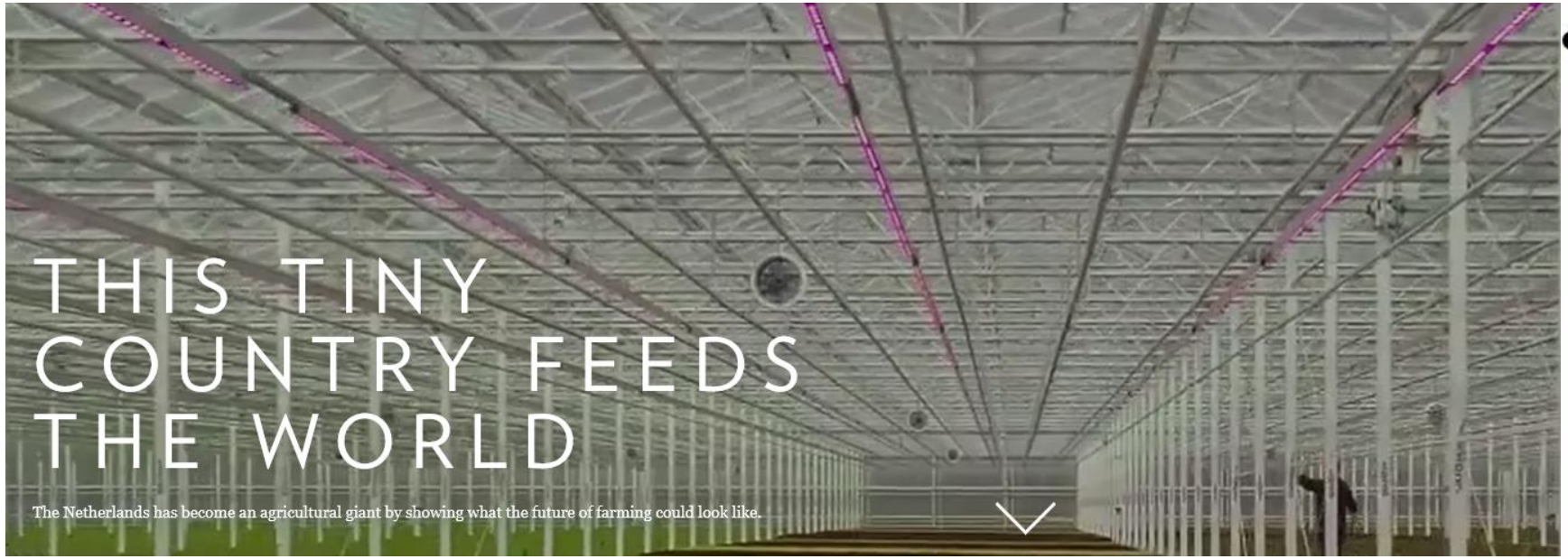
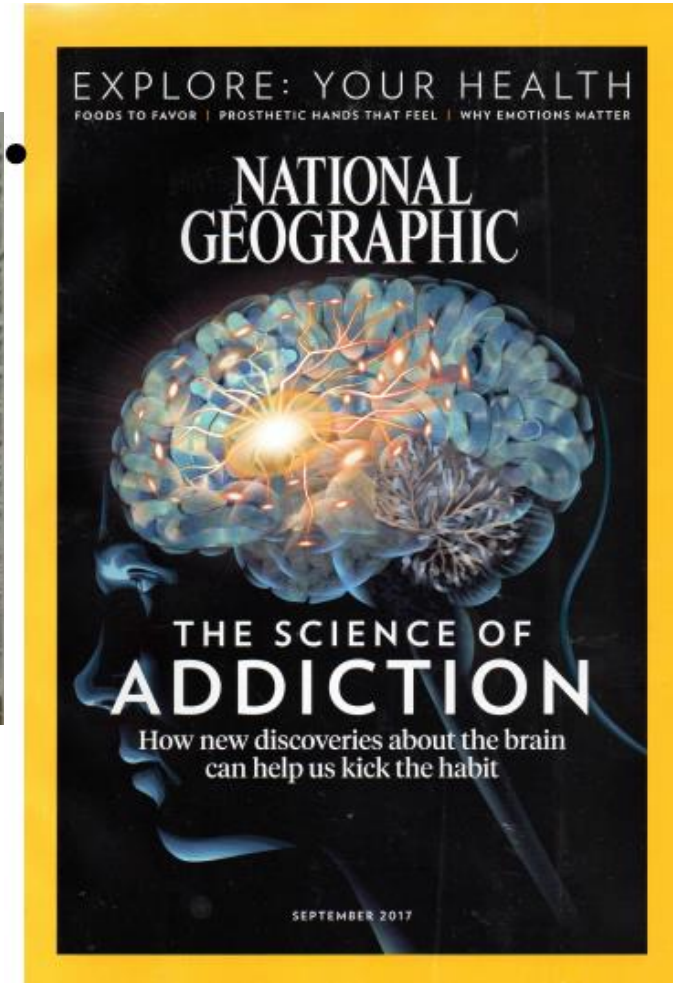
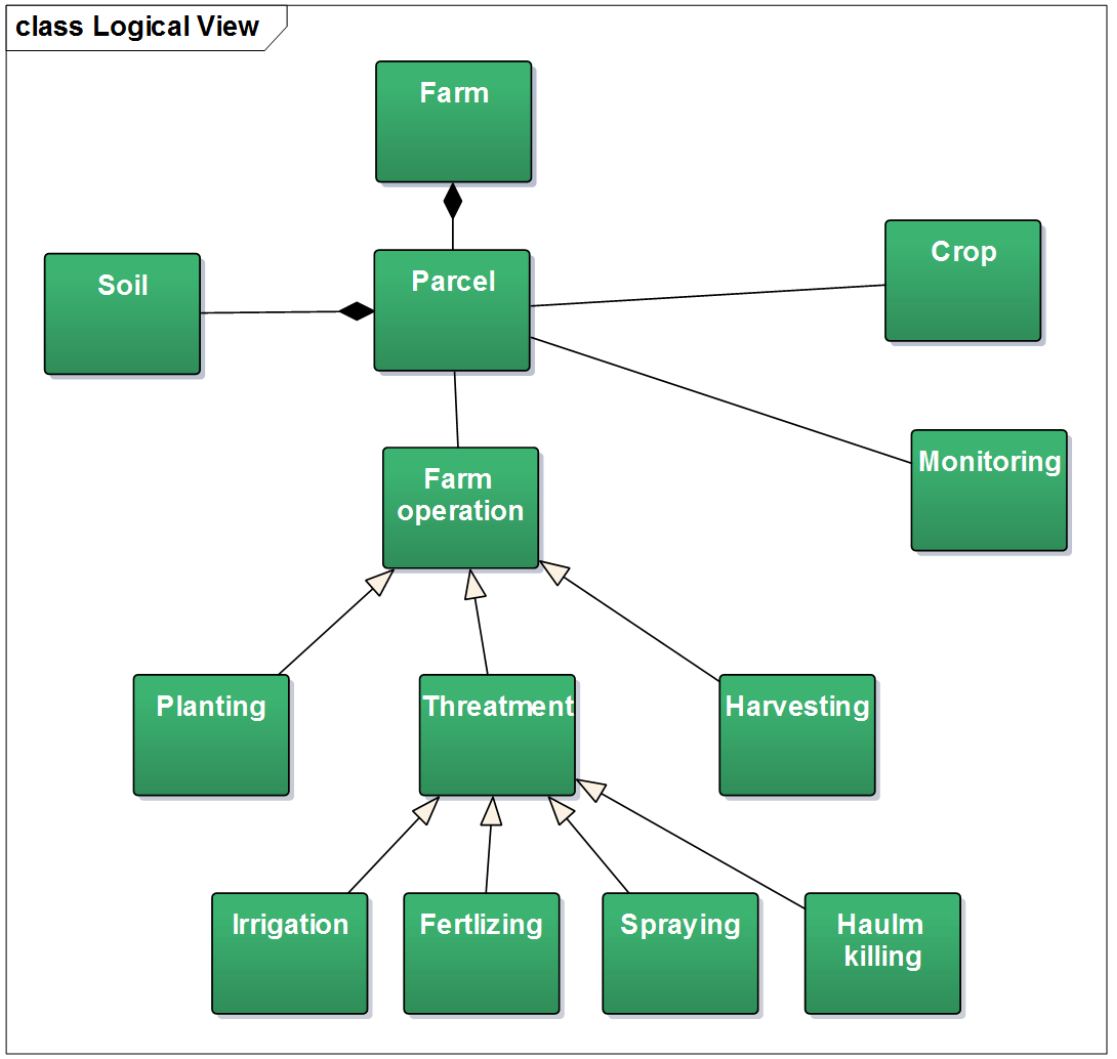
The Netherlands has become an agricultural giant





2nd largest exporter of agricultural products ($100 billion) in the world after the US

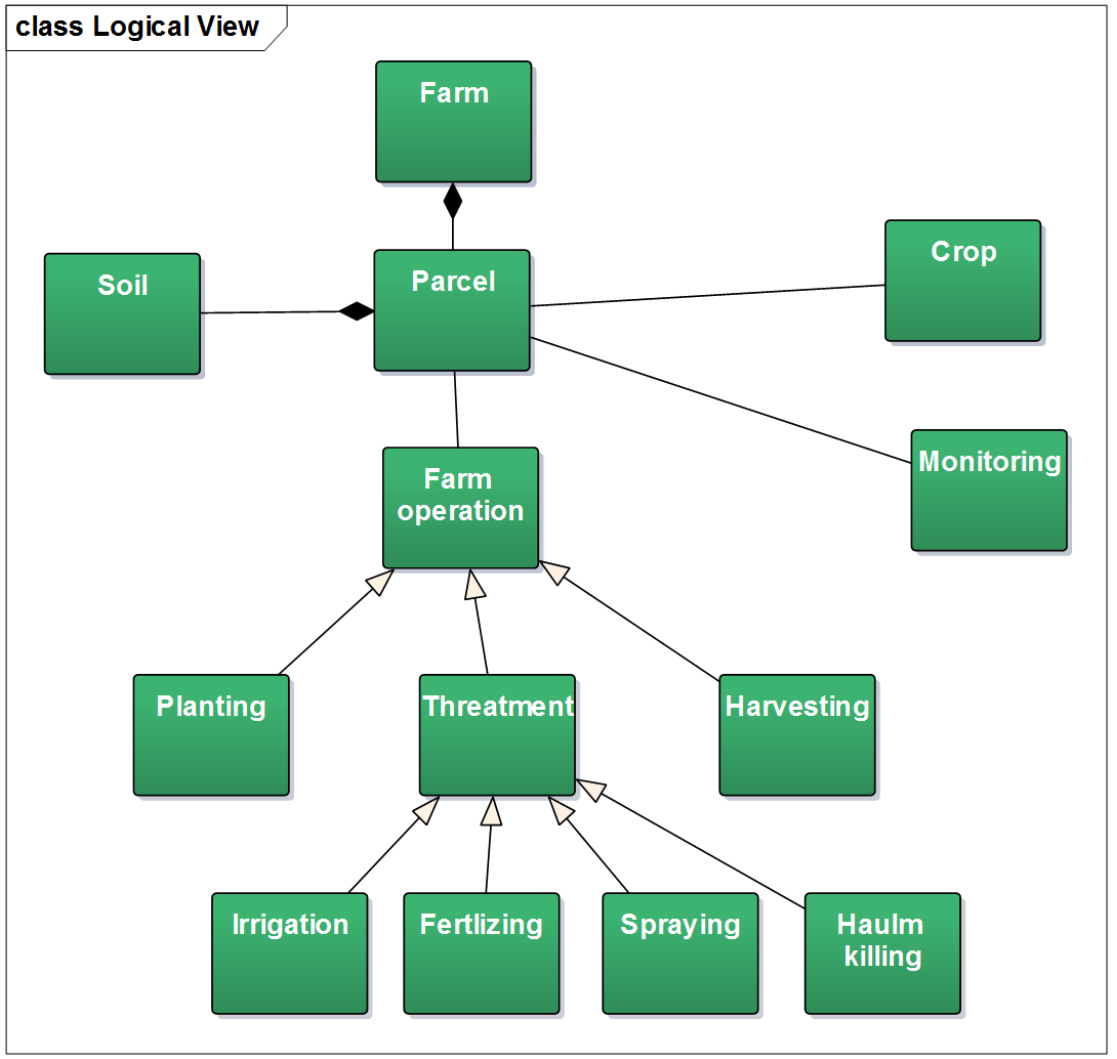
However…previous focus of innovation and business models was on producing *as much of food* products at the *lowest possible costs*



Feed People at low costs….. Oh yeah, what about Nature?

Source: P van Zoggel

Circular Agriculture



Sustainability

Global & Informed Consumers

My vision is to become leader in Circular Agriculture in the Netherlands

Minister Schouten of Agriculture, Nature and Food Quality (LNV)

Source: Visie minister Carola Schouten op landbouw: kringloop en het samen doen

LNV formulating a digitalization strategy to implement the circular agriculture vision; *incl. What is Legal status of data?; Who can access data?; How to ensure validity of data? And so on.*

Europe's ambition, e.g. to reduce use of mineral fertilizer by 30%, chemical pesticides by 50%, etc.

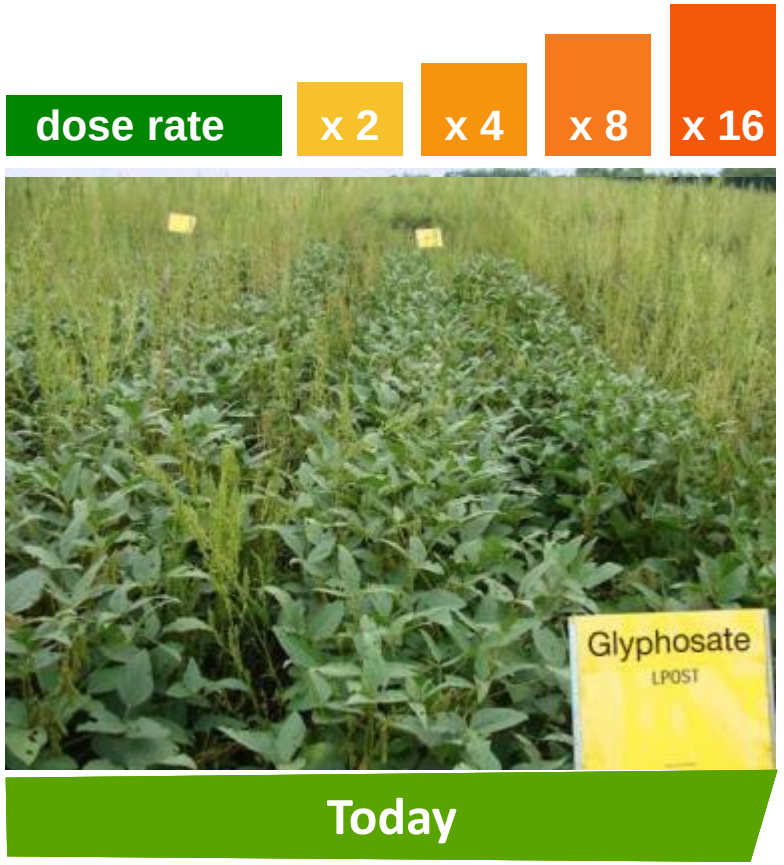
Increasing resistance to use chemical pesticides worldwide

The success of Roundup® resulted in the nearly exclusive reliance on glyphosate for weed control…

1996

The Success Story...

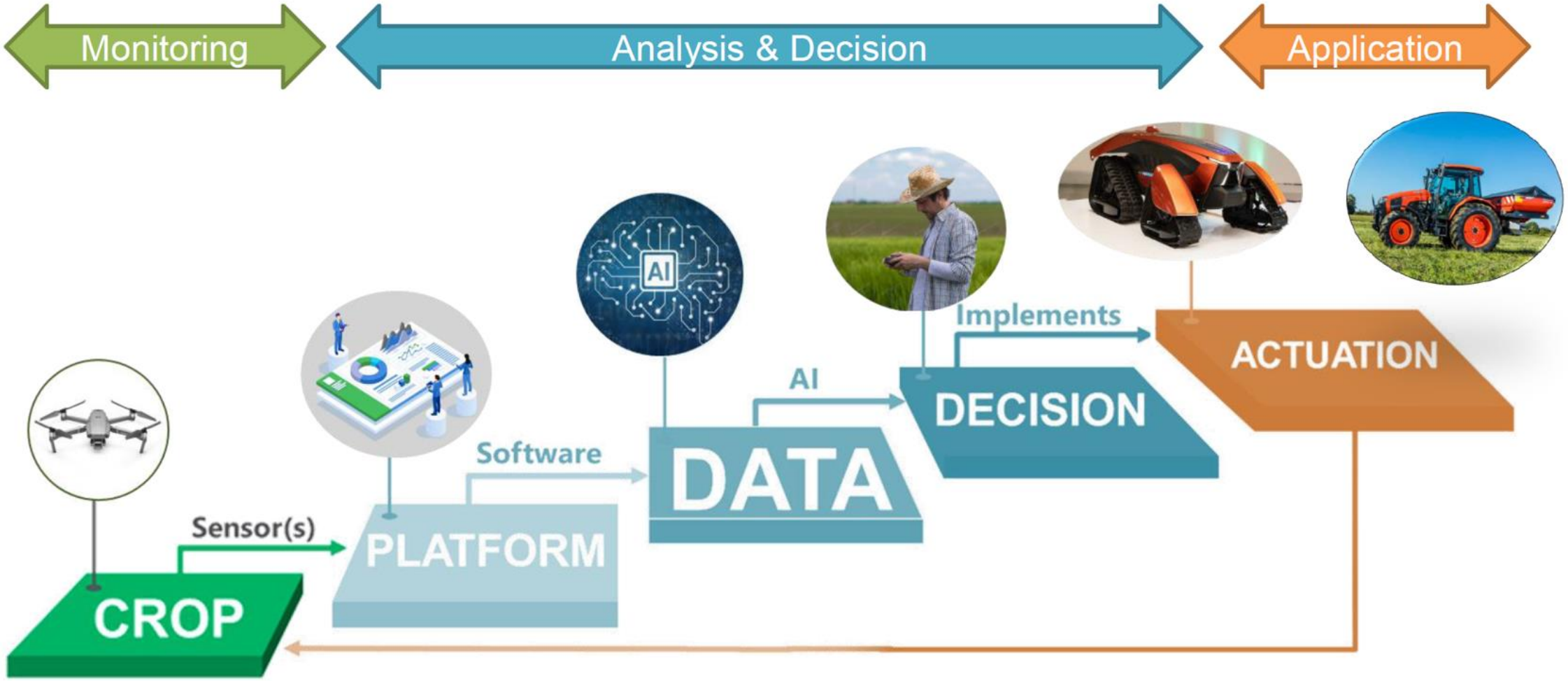
… this caused massive development of weed shifts and resistance...



Today

But Nature Strikes Back

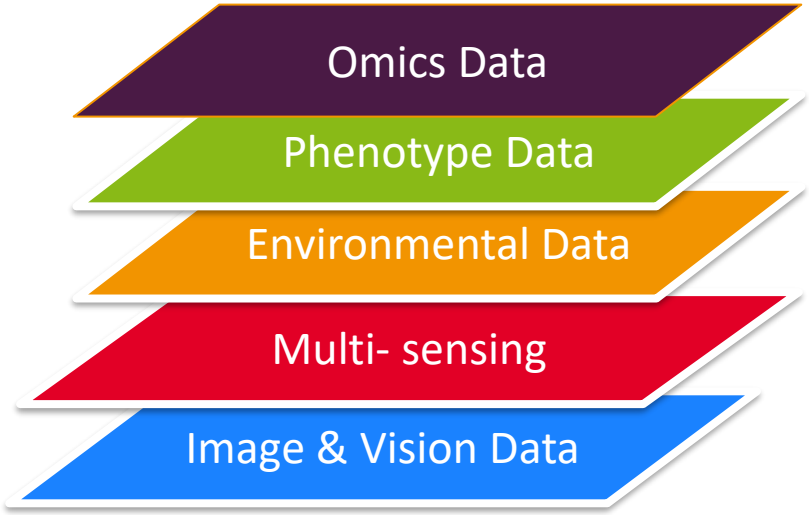
Precision farming dependent on data fusion, interoperability and security



Picture source: Peter van der Vlugt, General Manager, Kubota Innovation Center Europe

ADS research group: *Integrative Data Fusion and Data Analytics*

Bring "Big Data" Layers together in FAIR based information system and glue these together by high quality ontologies



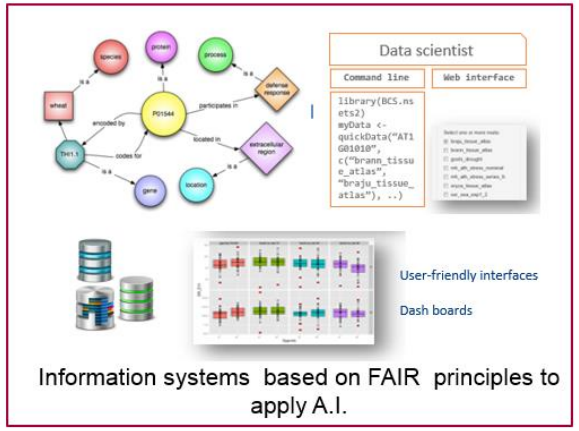
Integrative Data Analytics

Smart combining
- Deep learning
- A.I.
- Visualization
- Statistics
- And so on

Dash board

Data driven decisions

Predictive algorithms



Information systems based on FAIR principles to apply A.I.

FAIR –based data strategy

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TU/e

What is FAIR Data?

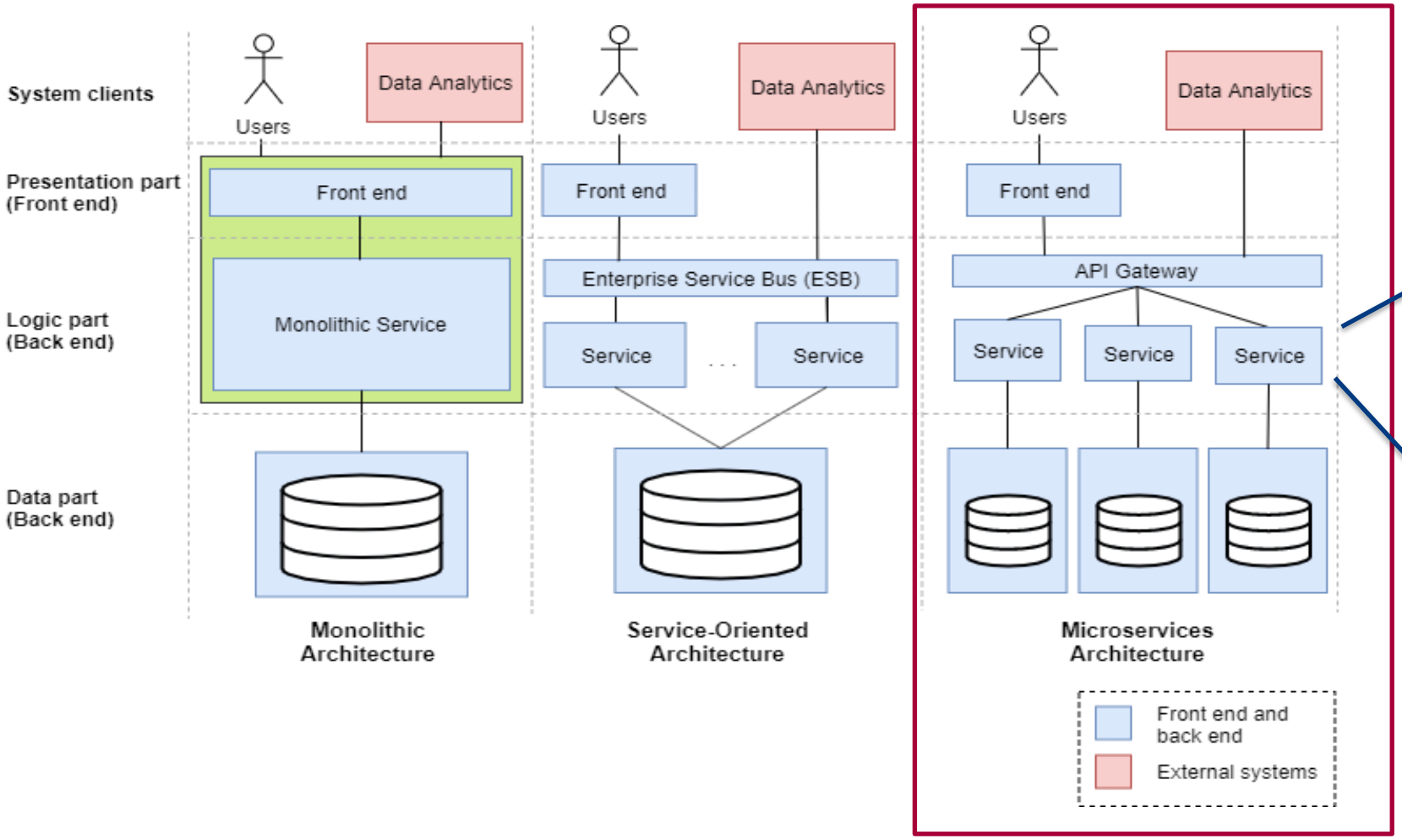
Findable - (meta)data is uniquely and persistently identifiable. Should have basic machine-readable descriptive metadata.

Accessible - identifiers should provide a mechanism for (meta) data access, including authentication, access protocol, license, etc.

Interoperable - (meta)data should be machine readable and annotated with resolvable vocabularies/ontologies.

Reusable - (meta)data is sufficiently well-described to allow (semi)automated integration with other compatible data sources

Data Fusion: *microservice and layered architecture to deal with many (distributed) cross-type data sources & sensors*



Microservice Architecture

Data Lakes

Sensor Devices

Meta data based ETL* to integrate

- Sensing data
- Historical
- External data
- Data lakes

*ETL: Extract-Transform-Load

Digital Transformation starts with organizational knowledge; *ability to ask the right data-driven business question together*

1. **Data Fusion**
(internal & external data; *consistency and accuracy)*

Smart Data Analytics
(machine learning, visualization, A.I. and so on)

FAIR–based digital architecture; *share and (re) use data; machine readable/ integration*

Visualize & ask team questions;
dialogue, validation, *what data is missing? quality of data?*

new experiments & find / validate new/relevant data sources

Is A.I. in AgriFood real or is it just a hype?

AlphaGo Zero is probably the world's best Go player, but it could do much more. | Sam Byford

Reinforcement learning: No guidance or previous human expertise needed

Learn by running millions of tests and give rewards via a evaluator algorithm for reaching certain goals

According to Google Reinforcement Learning can solve many problems in Industry….

PixelFaming-Robotics: developing agricultural robots (AgriBots)

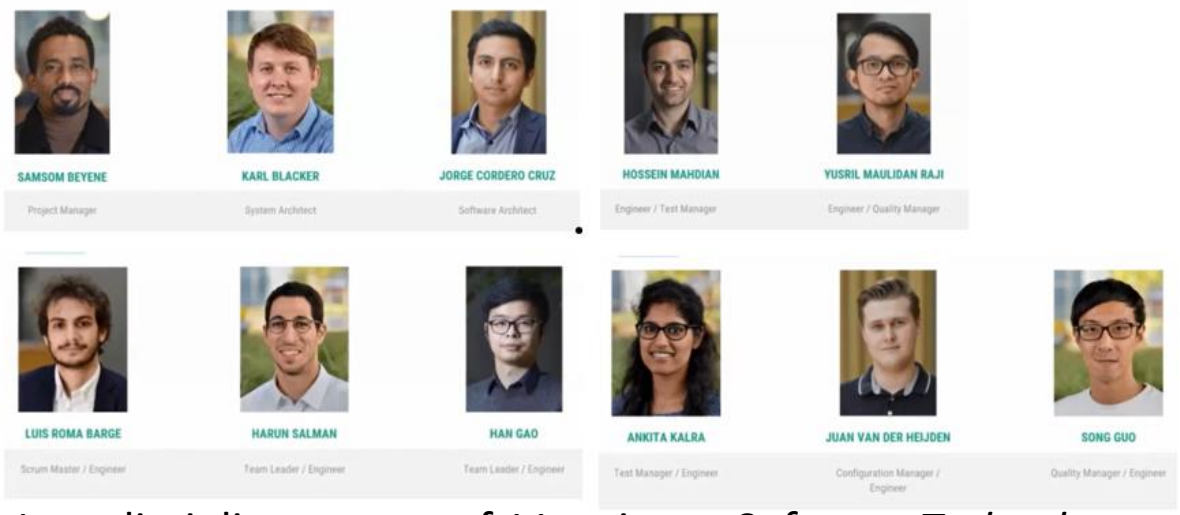
PIXELFARMING

There must be a better way to grow crops in a sustainable way...

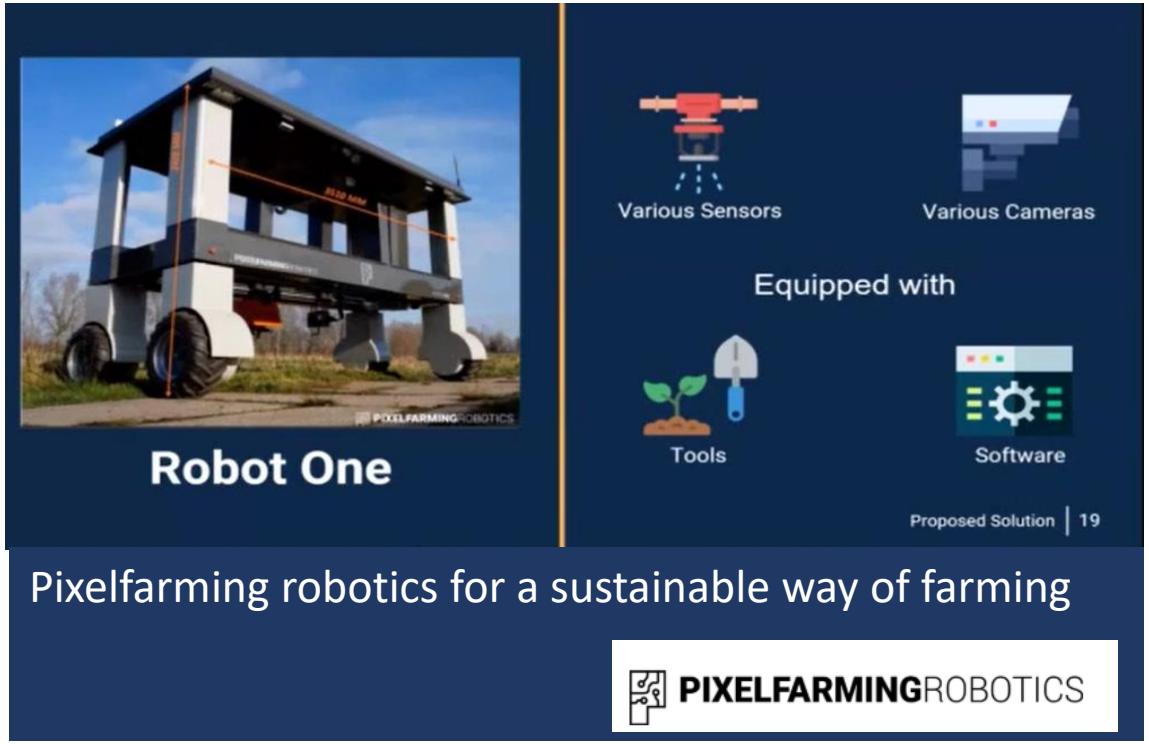
Arend Koekoek
Owner Pixelfarming
and **founder of Campus-Almkerk**

Simone and Arend Koekkoek bought a farm with 10 hectares of land in Almkerk, the Netherlands, where they founded the Campus Almkerk. Here various companies are exploring ways to grow crops in a sustainable way.

Interdisciplinary PDEng Project team to work on the weed robot



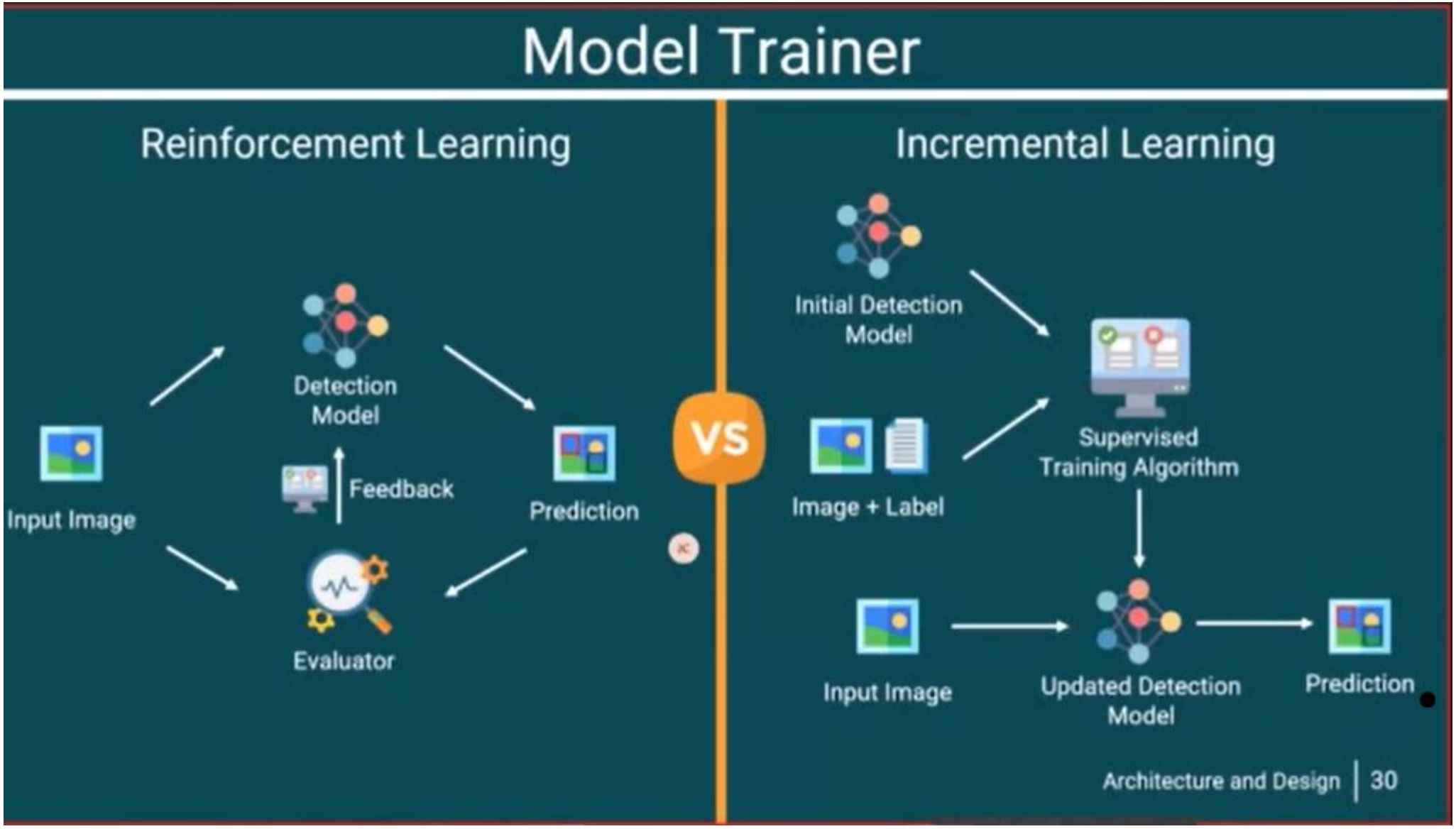
Interdisciplinary team of 11 trainees *Software Technology*, *Mechatronics* and *Mobility* Professional Doctorates in Engineering (3 months-project)



RobotOne using laser technology, computer vision, & A.I. for weed removal

A key challenge is ability to distinguish weeds from crops

What can A.I. do, in particular reinforcement learning?



Source: Interdisciplinary PDEng team, May 2020

Model Trainer

Reinforcement Learning

Requirements

- Process 10 images per second ?
- Detect weeds with high accuracy ?
- Retrain models in a short period +
- Retrain with images captured by RobotOne ?
- Available Implementation —

VS

Incremental Learning

Requirements

- Process 10 images per second +
- Detect weeds with high accuracy +
- Retrain models in a short period ?
- Retrain with images captured by RobotOne +
- Available Implementation +

Not amount of data or A.I. algorithm decisive for success

*…but ability to **label sufficient** data & deal with **changing** circumstances*

Alphabet's X, radical solutions to some of the world's biggest problems; 3 criteria

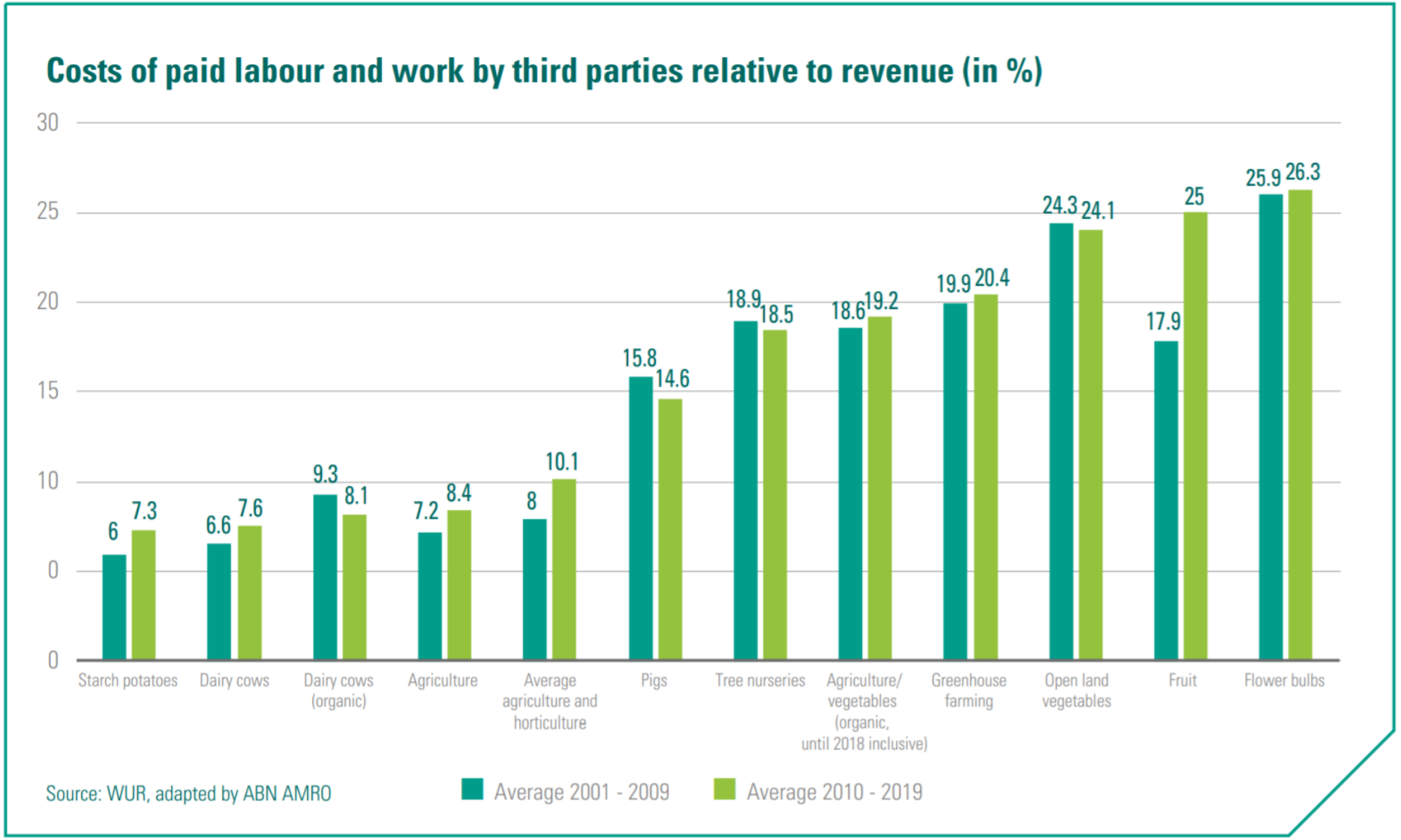
- Potentially solve a problem that affects millions or billions of people
- At least a glimmer of hope it's achievable within five to ten years.
- It has to involve a daring, sci-fi-sounding technology

HighTech and A.I. will have a huge impact on the future of the Ag&Food sector

ABN·AMRO Report August 2020

Dutch AgriTech market will triple in coming 10 years: from 715 million towards 2500 Million Euros.

Increasing *labor costs* and *labor shortages* in AgFood sector



Source: Labor costs in the Netherlands, ABN-AMRO report, August 2020

Food value chain integration & chain reversal has become possible by Data and A.I.

Precise

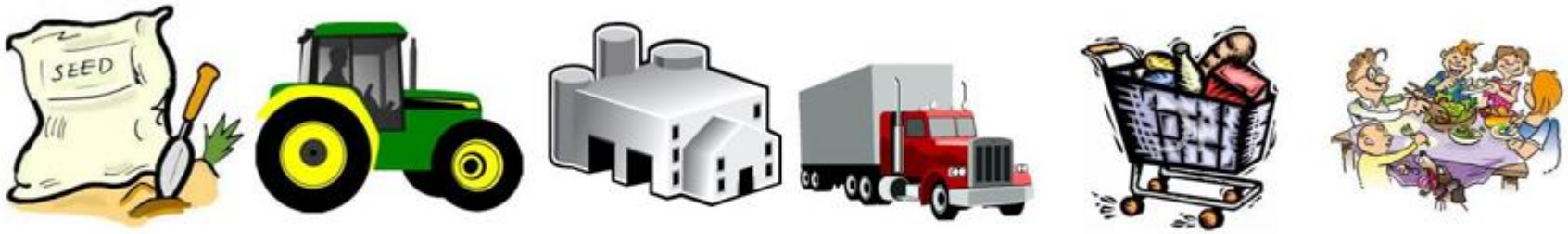
Value

Optimize operations & Price

Shorter & optimized Production chains

Enabled traceability

Consumer driven



Input → Farm → Processing → Distribution → Retail → Consumer

Reduce input & resources

Reduce waste & GHG emissions

Predict market dynamics

Anticipate demand & supply

Circular

Systems Integration to *rewrite* business models

Connected

Blockchain technology to allow traceability in the food value chain

MARS Food uses blockchain to revolutionize supply chain tracking

Carrefour zet blockchain in voor verkoop van kip

door Nina van Hoof - 7 maart

Blockchain improving turkey traceability

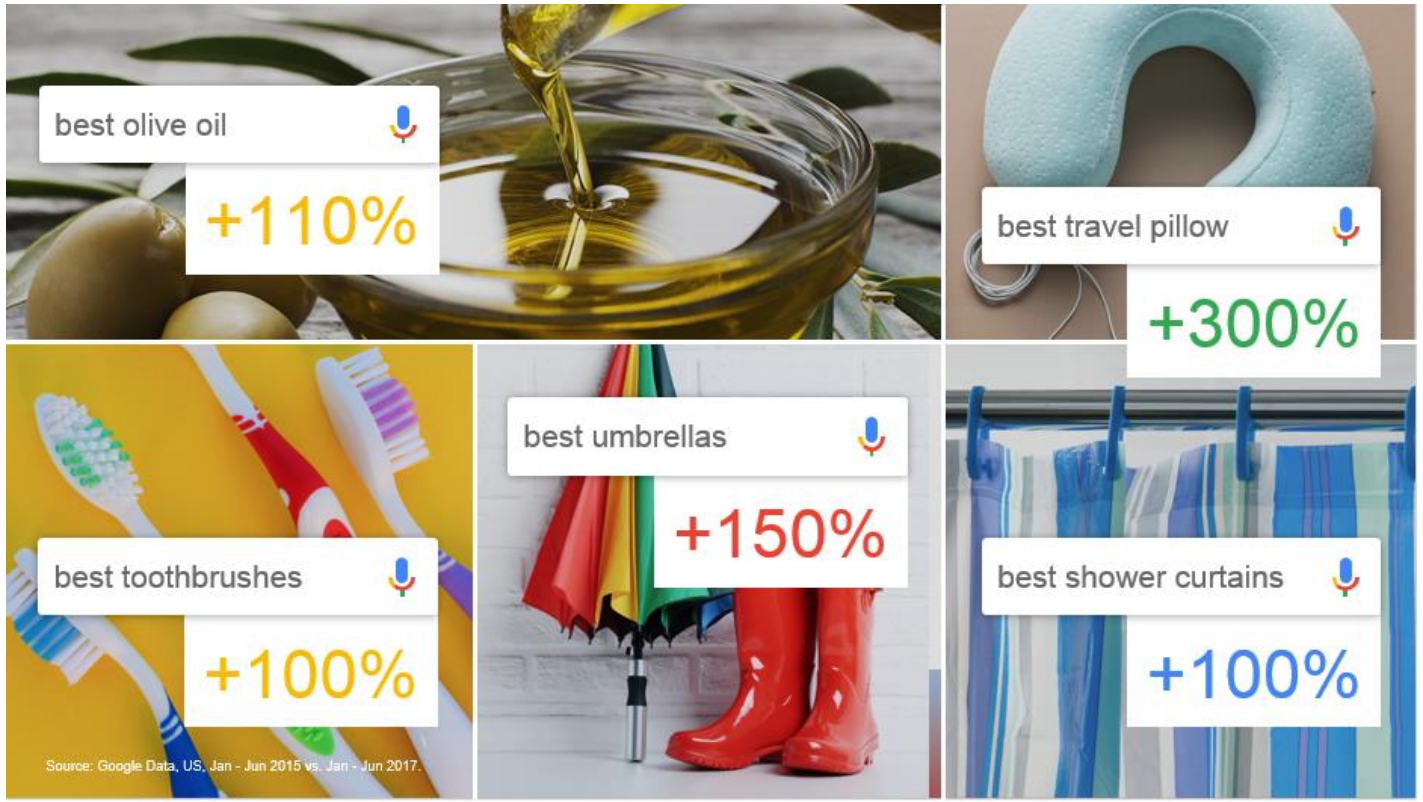
Cargill

Last year Cargill trialled blockchain technology that allowed consumers to trace their festive turkey back to the farm on which it was reared.

Data technology can provide proof of origins, treatment insights and production methods of our food. How will consumers respond? What new business models?

Mobile *is fastest growing technology of all time*

Mobile give consumer the power to get what they want ….
…AND companies' insight what to develop, produce and sell…



Google

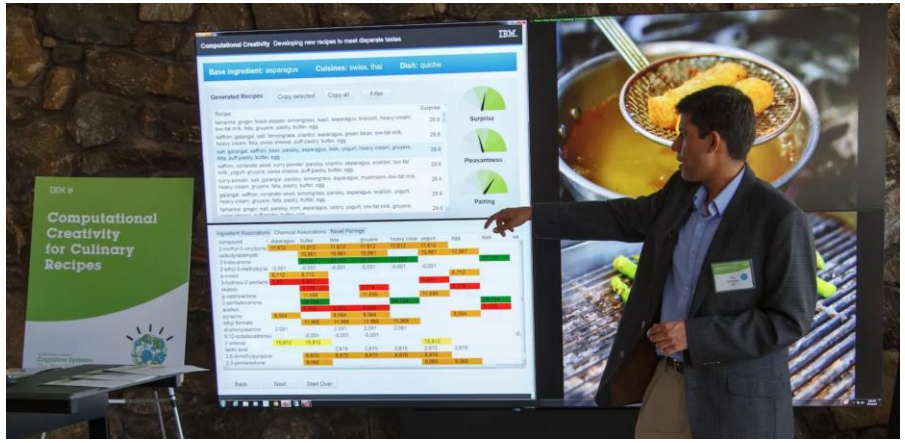
Smart phones made customers “research-obsessed”: *even research small, seemingly mundane things*

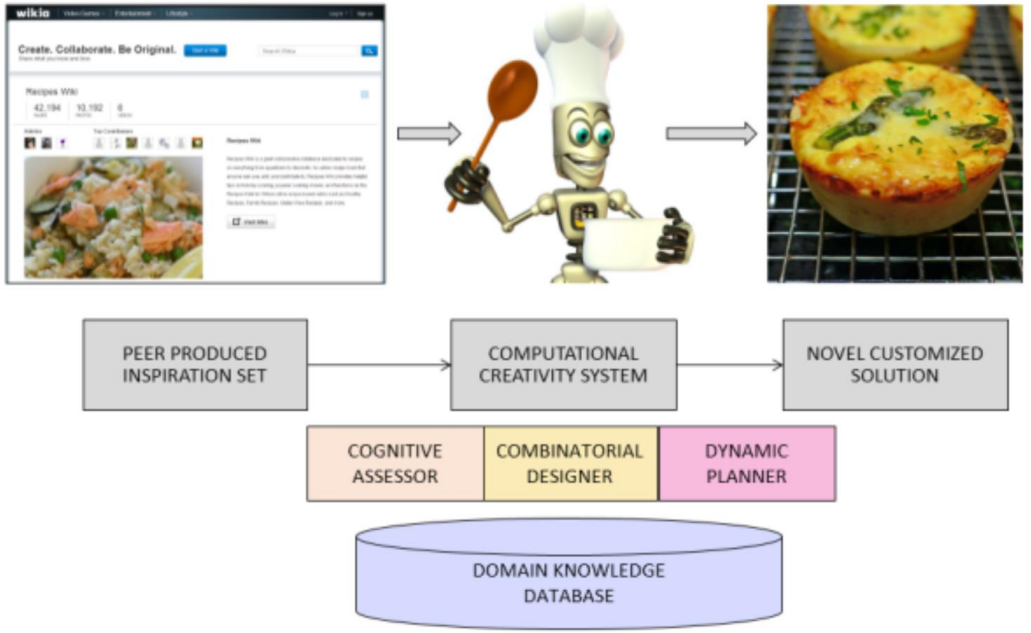
Jumbo's recipe to test how digital marketing influences in-store behaviour

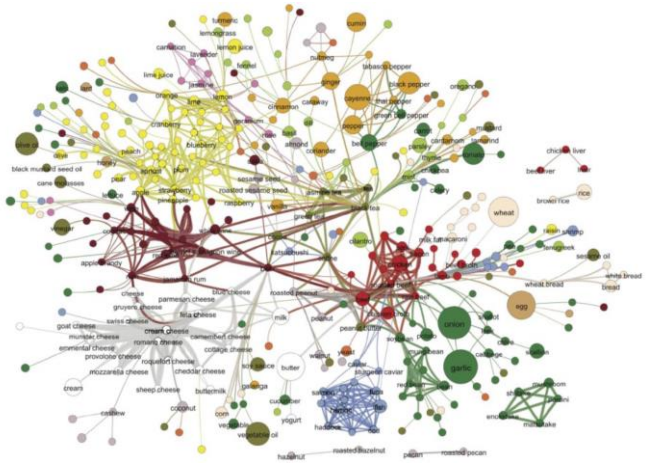
June 2019 / Benelux, Netherlands, Retail, Case Studies

Jumbo acquired Smulweb (the Netherlands' largest online recipe community),

IBM Chef Watson using big data to discover and create new recipes







Flavor compound network

Predictive algorithms by connecting data of 9000 recipes at “Bon Appetit website”, flavors, ingredients & ingredient pairings and human perception data

Short food chain: *produce local, unique food products delivered at your doorstep*

Amazon verrast met aankoop Whole Foods voor $14 mrd

Webwinkel Amazon (AMZN: $986,79 +2,35%) koopt de luxe supermarktketen Whole Foods Market. Het internetbedrijf betaalt $42 per aandeel voor de supermarkten, waarmee de totale waarde van de deal uitkomst op ongeveer $13,7 mrd. Dat hebben de beide bedrijven vrijdag bekendgemaakt.

Volgen via mi
Aandelen
Amazon

Several (technological & societal) developments

- Online platforms able **to find** your customers
- Better customer **understanding** by Big Data

- **Miniaturized** food processing equipment
- Sensing & data technology to validate quality and safety of **locally** produced food products **remotely**
- (Last mile) **logistics for fresh food products**

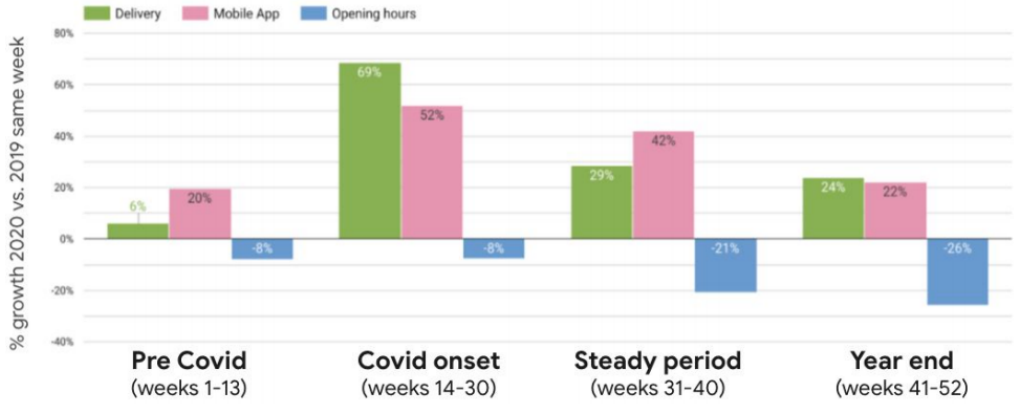
Can short food chains be translated in sustainable business model?

Food Unites The Netherlands! project proposal, Kwant & De Vlieg (UU/UMCU-WUR-TU/e alliance & FoodSwitch)

Shopping in new ways: fresh food delivery

Online has opened consumers eyes to new convenience channels - for essentials and beyond

Search interest for 'delivery', 'mobile app' & 'opening hours', worldwide



'milk delivery'[1]
+800%

'meat delivery service'[2]
+1,000%

'veg box delivery'[3]
+2,000%

NEW CONVENIENCE CHANNELS

Redefinition of habits post-Covid

Trigger:
Lockdowns disrupt triggers for convenience shopping (e.g. stores near work)

Ability:
Being at home dials up convenience of delivery; retailers respond with faster, streamlined fulfilment options e.g. same day, 3 hour delivery etc.

Reward:
Instant satisfaction: products are easy to order and delivered quickly

Motivation:
Motivation to use online channels as a 'better way' to shop increases as consumer confidence grows and they build new routines*

BEHAVIOUR LIKELY TO ENDURE

*Sunday is now most popular day in the Worldwide for search interest for 'delivery' up 64% in 2020 compared to same time period over last 4 years.[4]

Google

Sources: 1 Google Data, Global English, Feb 26 - Apr 25, 2020 vs Feb 25 - Apr 25, 2019 2. Google Data, Global English, Apr 1, 2020 - May 30, 2020 vs Apr 1, 2019 - May 30, 2019 3.Google Data, Global English, Apr 1, 2020 - May 30, 2020 vs Apr 1, 2019 - May 30, 2019 4. *Source: Growth in Search interest for each day of the week (Google Trends, May to Dec 2020 vs. last 4 years over the same period. Worldwide)

Source Google

New *Big Tech* players in AgriFood

Microsoft

Google

IBM

Innovation Industries

Alibaba

Tencent 腾讯

imec

amazon

What is the impact of the Platform Economy on the Agri&Food Sector?

Prof Martin Kenney
UC Davis

Platforms are already having powerful consequences for society, markets, and firms…whatever we call the transformation, the consequences are dramatic

Platform-Dependent Entrepreneurship: Power Asymmetries, Uncertainty, and Strategy*

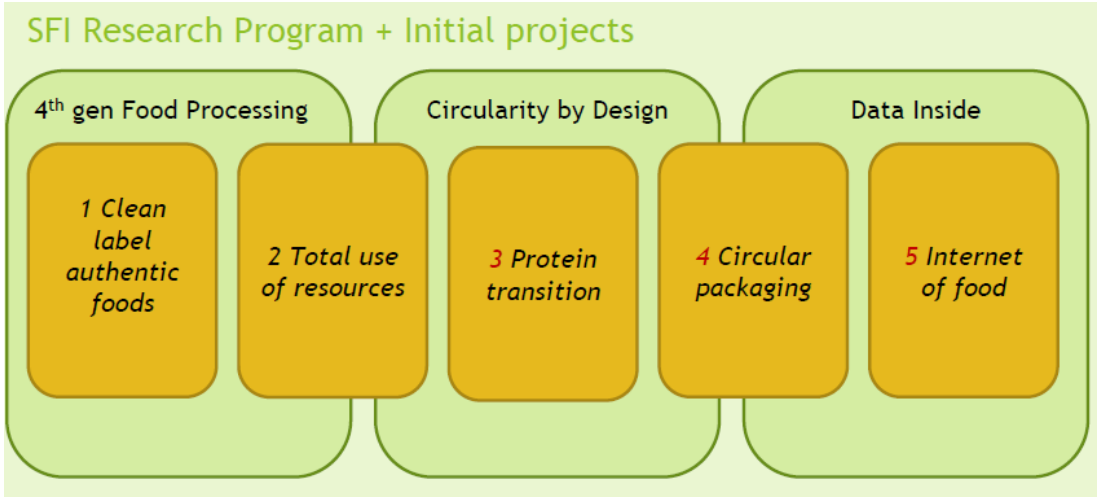
Martin Kenney
Professor
Community and Regional Development
UC Davis
&
Co-Director
Berkeley Roundtable on the International Economy

Data-driven AgriFood Future, 26 October, Den Bosch

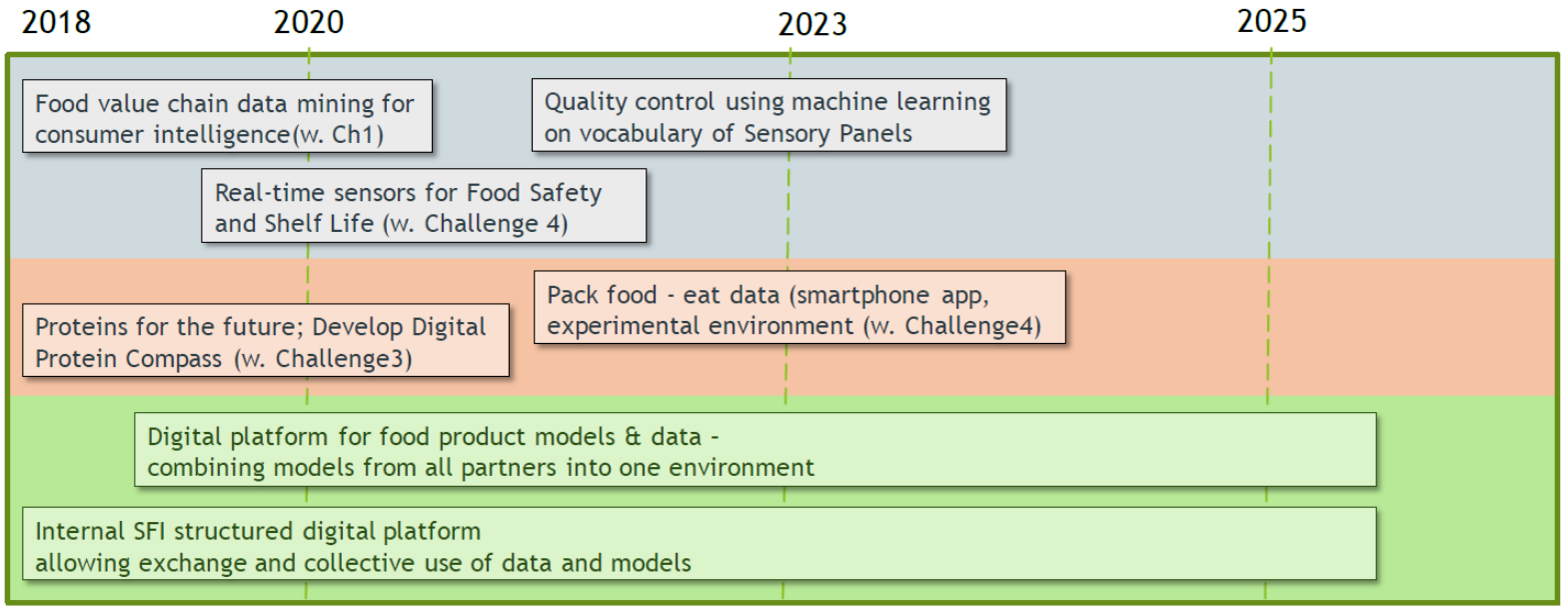
Sustainable Food Initiative

Join forces to produce healthy and safe food products at the lowest possible environmental footprint

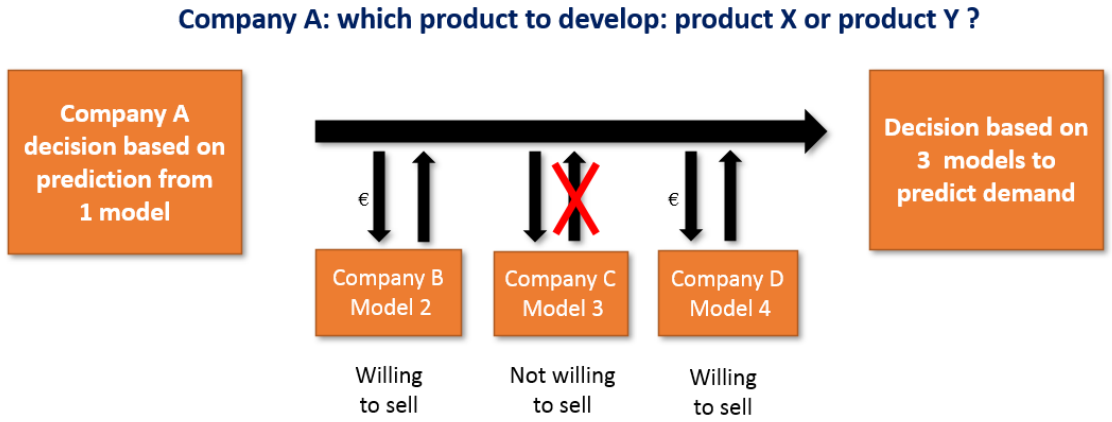
Create innovative community to connect deep fundamental research and fast innovation



Data Inside roadmap for digitally enhanced innovation in Foods



SFI *Internet of Food ((INoF) WP1*: *Digital architecture for the food sector to exchange (proprietary) food models to create new value together*



- Save costs by reusing expensive (proprietary) food models
- Stimulate inter-organization collaboration & creativity
- Speed up (sustainable) product development by reusing expertise
- Extend use of (in silico/simulation) models as actionable knowledge in the food industry

Software architecture & data requirements

- The software architecture should allow -**conditional-** sharing of models from different owners
- **Conditional sharing**: share food models without giving them away. Key words: protect IP, trust, pay for use
- **Interoperability** (*standardization of gateways, model exchange via web standards, decoupled, scalable, separation of concerns, and so on)*

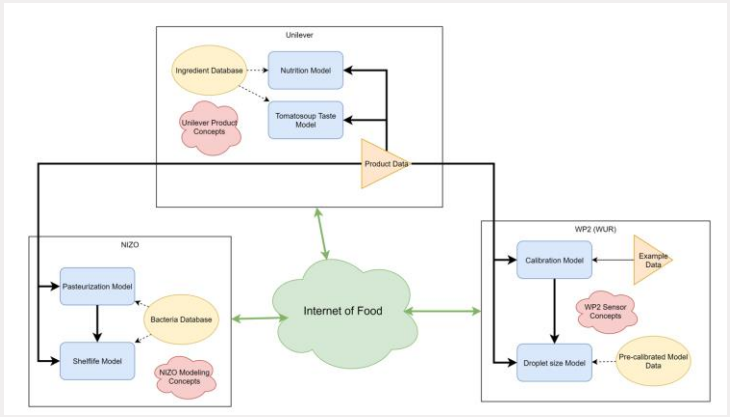
Funded by TKI Agri&Food

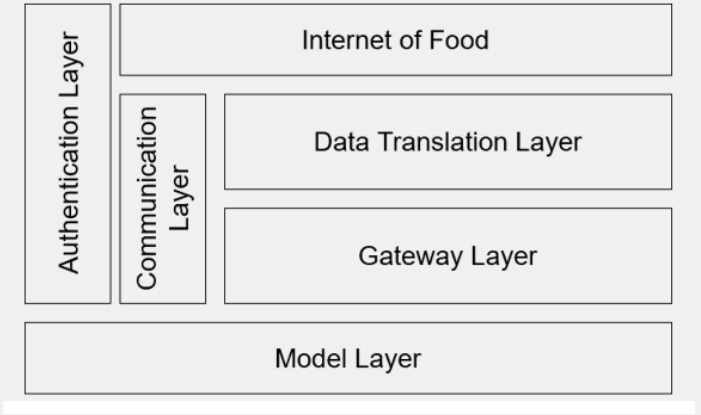
Connect expertise in models to speed up innovation

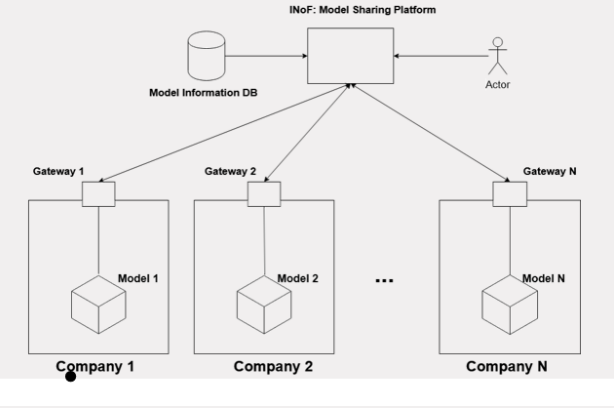
Picture source: Dr. Gribnau, Unilever R&D at RSC, UK, Nov. 2020

INoF digital architecture to ensure conditional sharing & interoperability

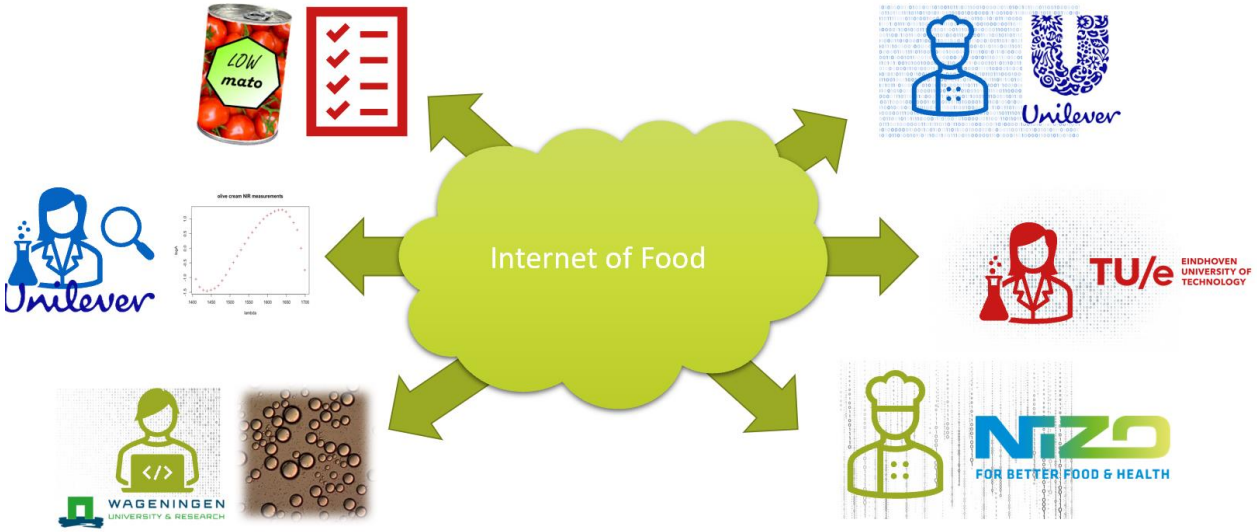
- Layered microservice architecture to deal with many (distributed) cross-type data sources, data lakes & (multi)sensing data
- Interoperability:
  - Dynamic model parameter mapping
  - Standardized interface boundaries & gateways for models and data (web standards)
  - Models that describe themselves by innovative ontology-based concepts (WUR & TU/e)
  - INOF architecture works as a hub in a hub and spokes model

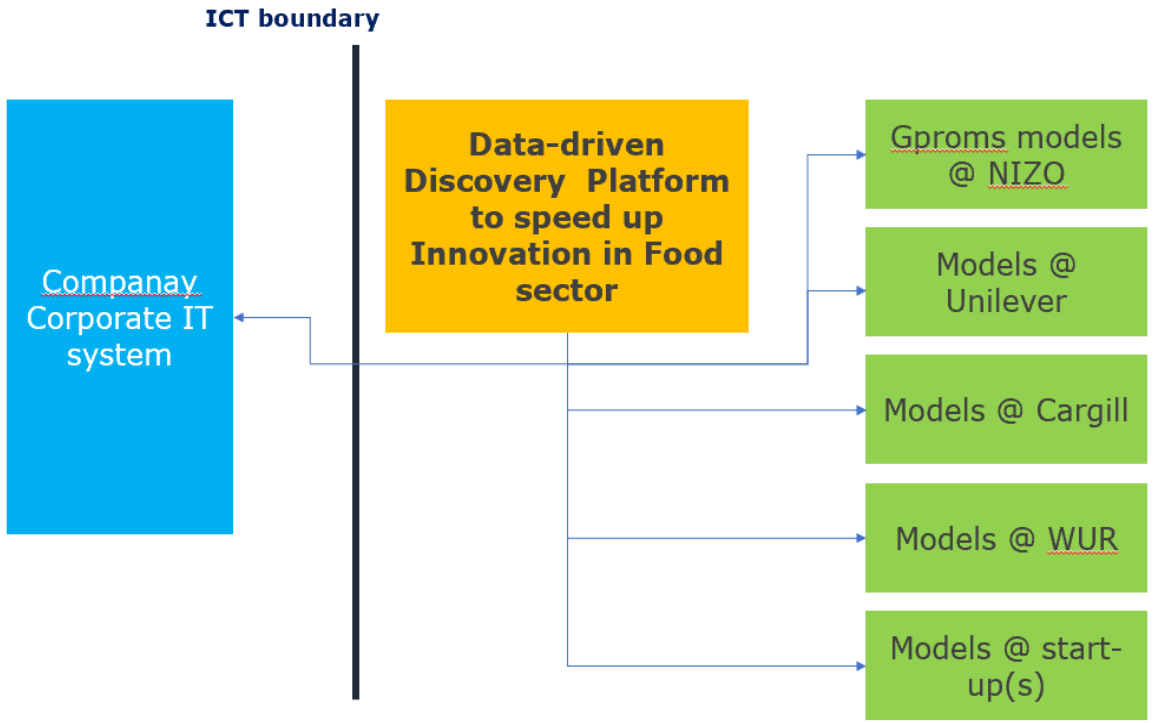






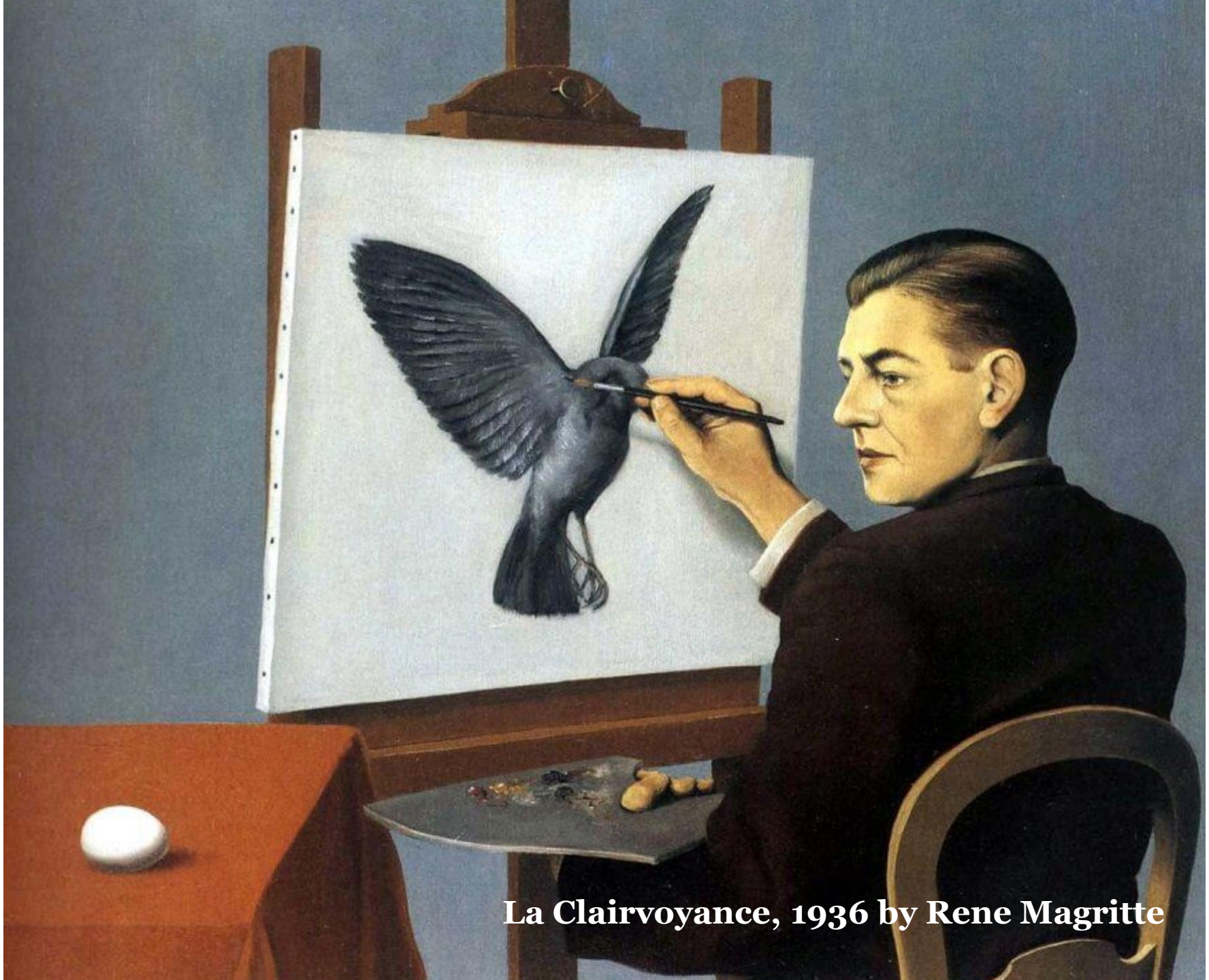
Four complex models combined: *shelf life, nutritional value, taste and microbiological stability*





Use case to validate & test INoF architecture:

How to develop a tomato soup with less salt by combining existing models?



La Clairvoyance, 1936 by Rene Magritte

Summary

Impact A.I. and cross-overs AgriFood & High Tech is huge

Worldwide increasing investments in AgriFoodTech

A.I. must be an integral part of the system and organization to be Successful; *ability to ask the right business question*.

Requires Team Science of entrepreneurs, students and scientists to connect deep fundamental research and fast innovation