AI.

Artificial Intelligence use cases in Agriculture

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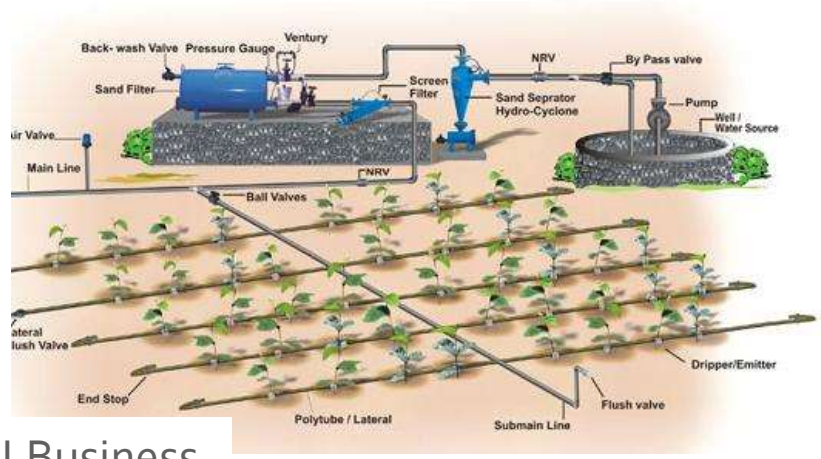
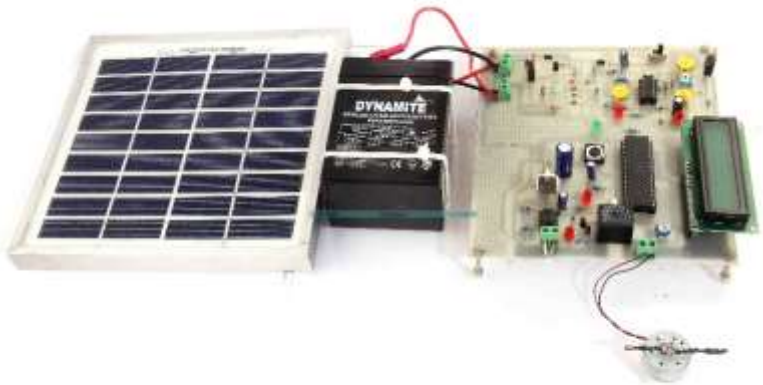
USE CASE – Automated irrigation systems

An automated irrigation system refers to the operation of the system with no or just a minimum of manual intervention beside the surveillance.

Several types of such systems exists

- **Closed Loop Systems –** *based on a predefined irrigation scheme the control system takes over and makes detailed decisions on when and how much water to apply*
- **Open Loop Systems –** *based on the amount of water to be applied and the timing of the irrigation*
- **Volume Based System –** *The pre-set amount of water can be applied in the field*
- **Time Based System –** *works with time clock controllers*





(Adapted from BOMAN et al. 2006)

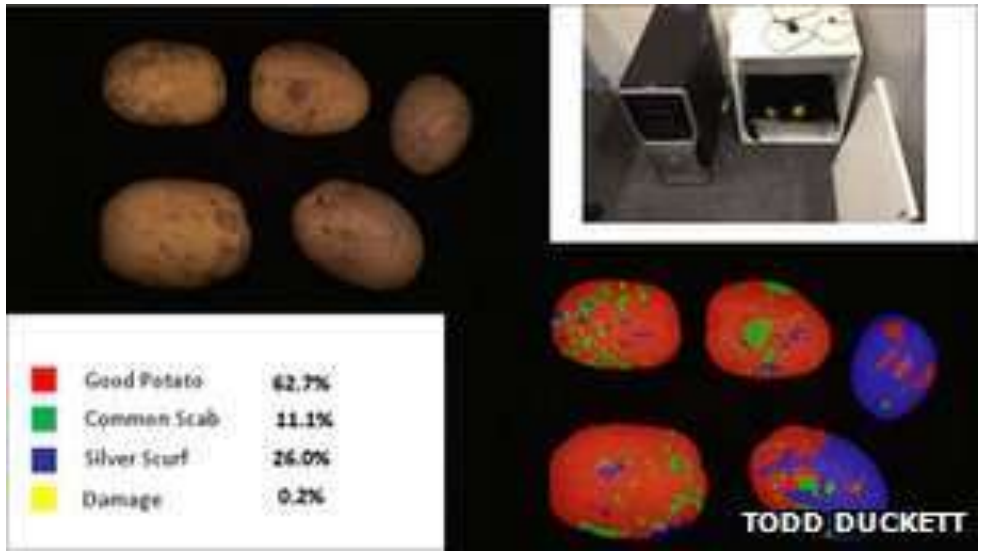
Automated irrigation systems: EFFECT OF USAGE

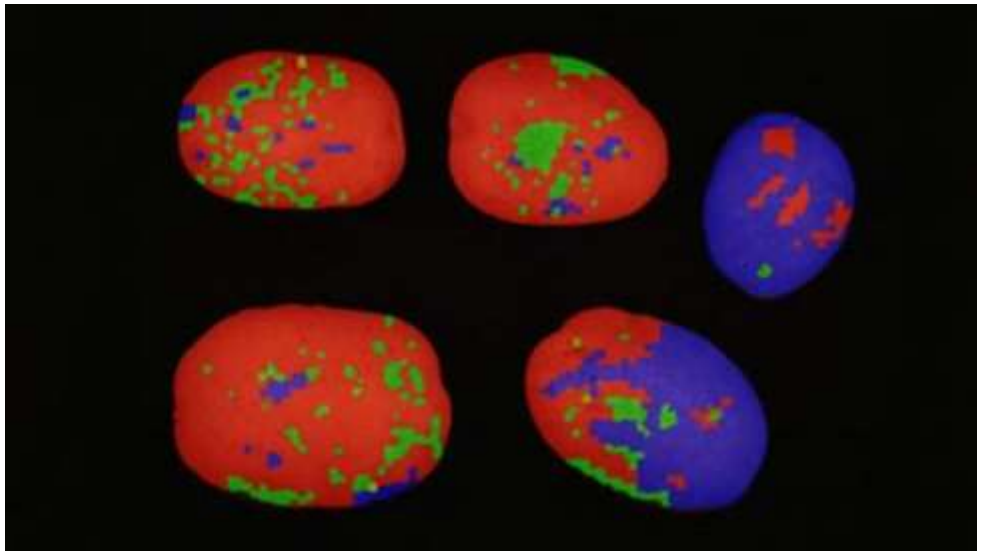
- Reducing production costs of vegetables, making the industry more competitive and sustainable.
- Maintaining (or increasing) average vegetable yields
- Minimizing environmental impacts caused by excess applied water and subsequent agrichemical leaching.
- Maintaining a desired soil water range in the root zone that is optimal for plant growth.
- Low labor input for irrigation process maintenance
- Substantial water saving compared to irrigation management based on average historical weather conditions.

Source: **Sustainable Sanitation and Water Management** (SSWM)
http://www.sswm.info/content/automatic-irrigation

USE CASE – TADD (Trainable Anomaly Detection and Diagnosis)
Potato sorting system

A robotic system that sorts and can detect diseases of potatoes





Potato sorting system
EFFECT OF USAGE

- Higher precision of detection of affected/unhealthy potatos versus manual selection in industrial scale
- Lower labor input
- Possibility for higher food safety assurance

Source: Lincoln Centre for Autonomous Systems
https://lcas.lincoln.ac.uk/wp/projects/

USE CASE - Drones for crop spraying

- Easy-to-fly devices that are designed to spray pesticides on crops.
- With drones it is also possible to capture high resolution images of whole field for further analysis.

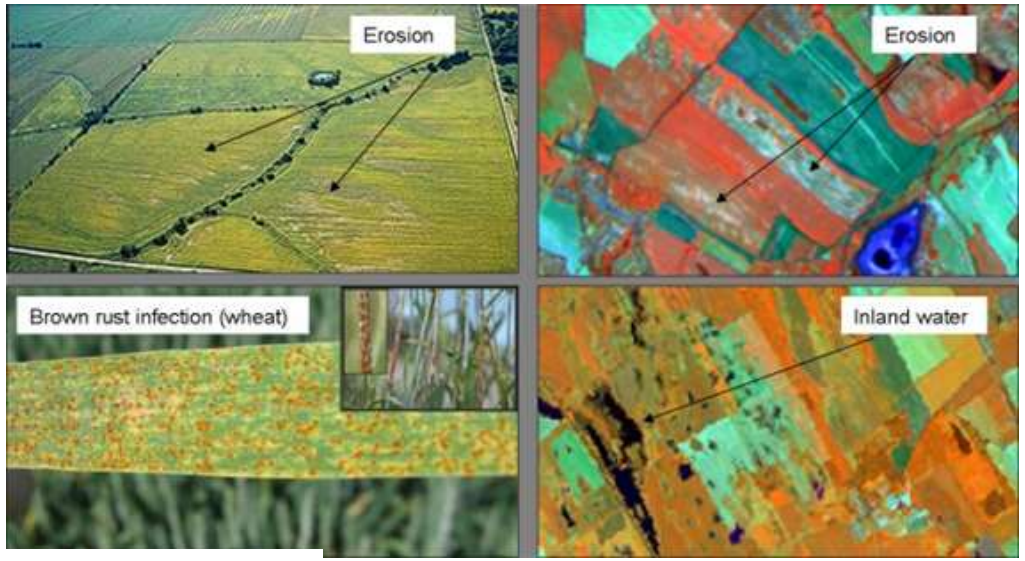
Drones for crop spraying
EFFECT OF USAGE

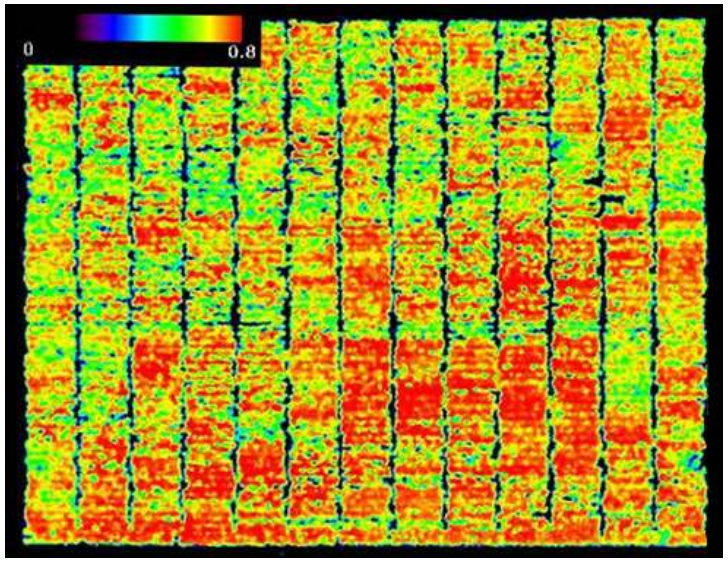
- Unmanned aerial vehicle (UAV) sprayer does not need a runway
- Drones can take off and land vertically.
- Flying at low altitude of several meters, the crop-spraying can be controlled in any the sight of distance range.
- Drones are suitable for all kinds of complex terrain, crops and plantations of varying heights.
- Precise and accurate crop spraying ensures the best coverage and application of your fertilizers or pesticides on your lands.

Source: Homeland Surveillance & Electronics LLC
http://www.uavcropdusterssprayers.com

USE CASE - Remote Sensing: Crop Health Monitoring

- Hyperspectral imaging and 3D Laser Scanning, are capable of rapidly providing enhanced information and plant metrics across thousands of acres with the spatial resolution to delineate individual plots and/or plants and the temporal advantage of tracking changes throughout the growing cycle





Remote Sensing
EFFECT OF USAGE

- Conventional methods are often time consuming and generally categorical in contrast to what can be analyzed through automated digital detection and analysis technologies categorized as remote sensing tools.
- The trained use of hyperspectral imaging, spectroscopy and/or 3D mapping allows for the substantial increase in the number of scalable physical observables in the field
- In effect, the multi sensor collection approach creates a virtual world of phenotype data in which all the crop observables become mathematical values.

Source: Galileo Group INC.
http://galileo-gp.com/applications/agriscience/

USE CASE - Face recognition systems for Domestic Cattle

- Facial recognition of cows in dairy units can individually monitor all aspects of behavior in a group, as well as body condition score and feeding.
- When it comes to lameness, measuring the arch in the cows' back could give an early sign of the problem.

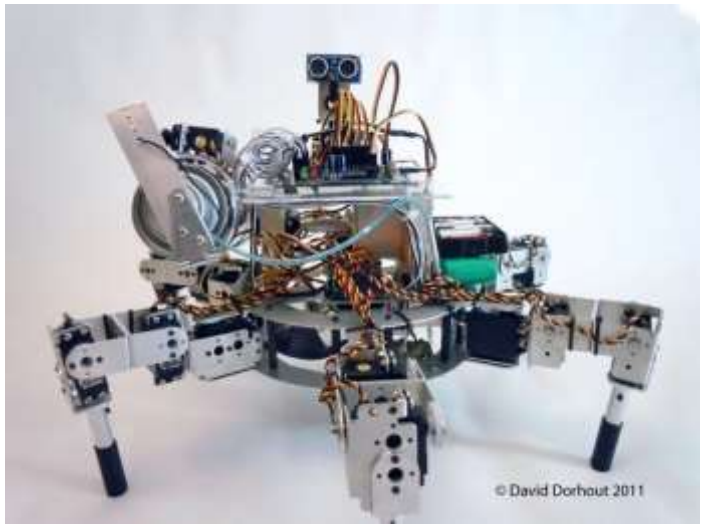
Facial recognition of cows
EFFECT OF USAGE

- With this system it is possible to feed cows a lot less expensively if you know what they will and will not eat.
- Possible to fix a lame cow before she shows you the signs of lameness, it can save months of lower production.

Source: *Bertrand L. Deputte et al. "Individual Recognition in Domestic Cattle (Bos taurus): Evidence from 2D-Images of Heads from Different Breeds"* http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0004441

USE CASE – "PROSPERO" THE SWARMING FARMBOT

- "Prospero" is the working prototype of an Autonomous Micro Planter (AMP) that uses a combination of swarm and game theory and is the first of four steps. It is meant to be deployed as a group or "swarm". The other three steps involve autonomous robots that tend the crops, harvest them, and finally one robot that can plant, tend, and harvest autonomously transitioning from one phase to another.



Swarm Prospero
EFFECT OF USAGE

- The application of the system increases the productivity of land on a per unit basis.
- A swarm of small robots like Prospero would have the ability to farm inch by inch, examining the soil before planting each seed and choosing the best variety for that spot.
- This would maximizing the productivity of each acre, allow less land to be converted to farm land, feed more people, and provide a higher standard of living for those people because they would spend less of their money on food

Source: Dorhout R&D
http://dorhoutrd.com/prospero_robot_farmer

USE CASE – Strawberry Harvesting Robot

- Automated harvester recently wheeled through rows of strawberry plants here, illustrating an emerging solution to one of the produce industry's most pressing problems: a shortfall of farmhands.

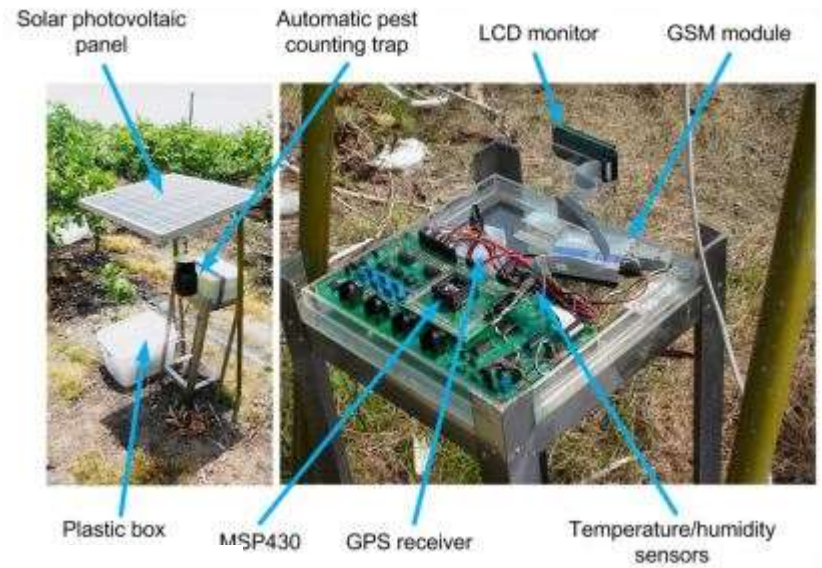
Strawberry Harvesting Robot
EFFECT OF USAGE

- Increased mechanization of the fresh-produce industry boosts productivity, ultimately helping to tamp down price growth.
- It also help farmers, who are struggling with a yearlong drought in the country's largest produce state, get more from their fields, offsetting higher costs.
- The system allows to avoid the labor shortages, existing in many developed countries

Source: Agrobot LLC
http://www.agrobot.com/

USE CASE - Autonomous Early Warning System for Oriental fruit fly (*Bactrocera dorsalis*) outbreaks

- This autonomous early warning system, built upon the basis of wireless sensor networks and GSM networks effectively captures long-term and up-to-the-minute natural environmental fluctuations in fruit farms.
- In addition, two machine learning techniques, self-organizing maps and support vector machines, are incorporated to perform adaptive learning and automatically issue a warning message to farmers and government officials via GSM networks.



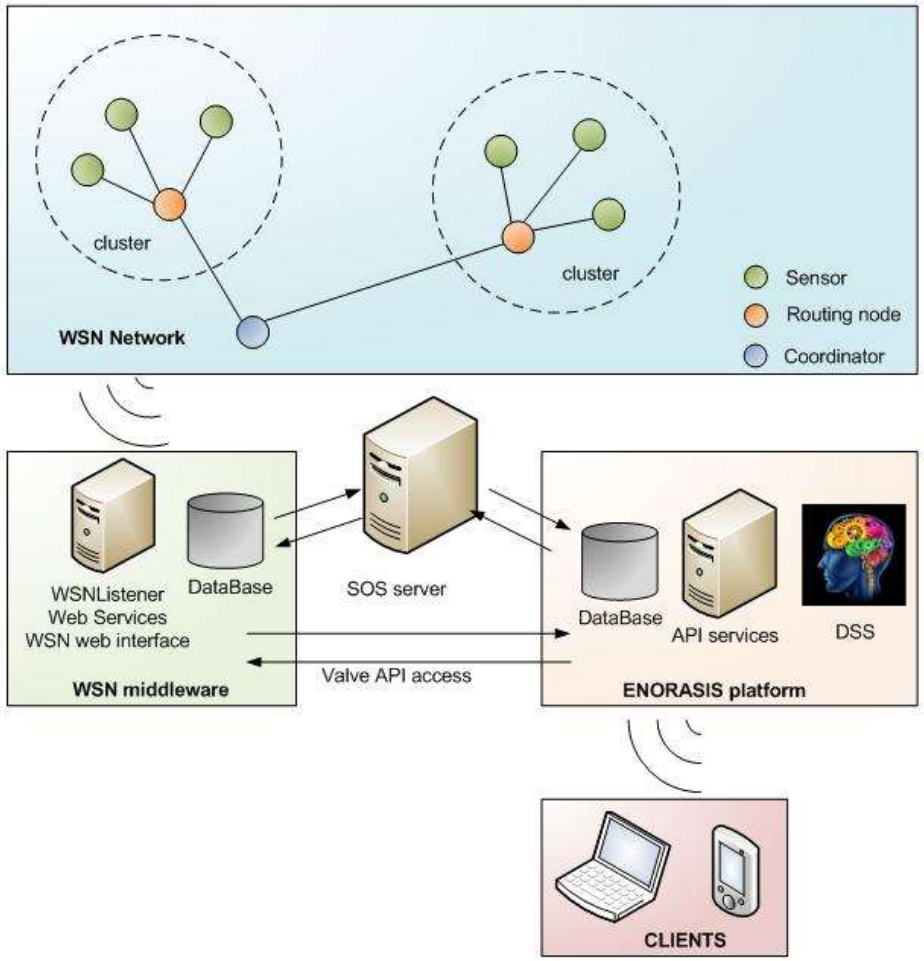
Autonomous Early Warning System
EFFECT OF USAGE

- The use of autonomous early warning system for detecting pest resurgence is an essential task to reduce the probabilities of massive Oriental fruit fly outbrakes.
- By preventing pest outbreaks, farmers would be able to reduce their dependence on chemical pesticides. Chemical pesticide abuse often brings harmful consequences to human health and natural environments.
- The proposed early warning system can be easily adopted in different fruit farms without extra efforts from farmers and government officials since it is built based on machine learning techniques, and the warning messages are delivered to their mobile phones as text messages.

Source: Min-Sheng Liao et al.
http://www.sciencedirect.com/science/article/pii/S016816991200172X

USE CASE - The ENORASIS Wireless Sensors Network

- The ENORASIS project uses a network of sensors in the fields to determine how much water to give their crops through subsurface drip and micro-irrigation systems. The sensors collect environmental and soil conditions such as soil humidity, temperature, sunshine, wind speed, rainfall and the water valves to quantify water already added to the fields.



Enorasis
EFFECT OF USAGE

- ENORASIS combines weather forecast and sensor data about the farm's crops to create a detailed daily irrigation plan that best suits the needs of each crop.
- The model also includes crop yield data and energy and water costs, helping farmers decide whether extra irrigation will increase yields profitably or cause a loss.

Source: Enorasis
http://www.enorasis.eu/page/ENORASIS_wireless_sensors_network

USE CASE – "VEEPRO": information center for Dutch (dairy) cattle

- This AI expert system is able to prescribe feed rations, medications, health and welfare conditions for livestock
- It can recommend the mating partners for improving genetic potential of offspring.
- The expert system is able to perform complex analysis of health, reproduction status of individual or groups of animals, to keep track of production and recommend operational measures to be taken in order to improve the farm performance

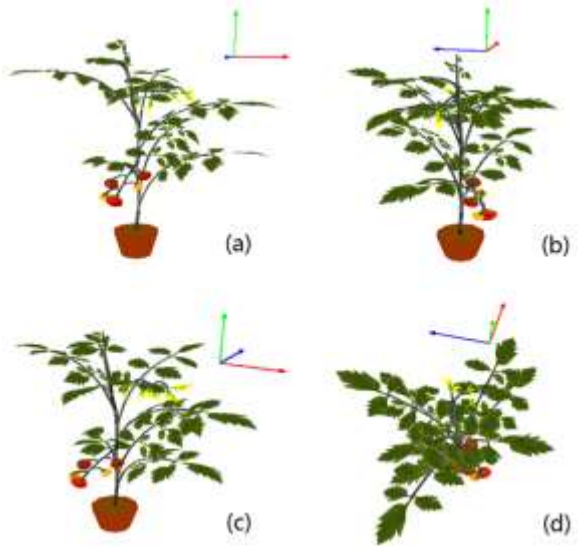
VeePro
EFFECT OF USAGE

- Gives information about dairy cattle improvement and health care.
- Supports dairy husbandry, dairy cattle improvement and health care.
- The system can develop and implement fine-tuned breeding programs. The most important selection criteria are milk production, fat and protein percentage, age durability, functional traits (udder, feet and legs), fertility, health, calving ease, and type. The indexes for calculating the breeding values are constantly updated according to the newest scientific insights.

Source: VeeproHolland
http://veepro.nl/

USE CASE - Decision Support System (DSS) for Greenhouse Tomato Yield Prediction using AI Techniques

- This system involves a set of Artificial Intelligence based techniques:
  - Artificial Neural Networks (ANNs)
  - Genetic Algorithms (GAs)
  - Grey System Theory (GST).
- Use of artificial intelligence based methods can offer a promising approach to yield prediction and compared favorably with traditional methods.



DSS for Greenhouse
EFFECT OF USAGE

- The system allows to predict the environmental conditions that influence the growth and productivity of tomato plants including air temperature (day and night), fruit temperature, radiation, CO_2 concentration, fruit load, plant density, stress etc.
- DSS makes possible to adjust the fluctuation of temperature affecting mostly the time of fruit ripening and rate of fruit growth.

Source: University of Warwck, UK
http://www.irma-international.org/viewtitle/56210/

USE CASE – Precision Lettuce Thinning by "BLUE RIVER TECHNOLOGY"

- A lettuce-thinning robot in California, is used for the thinning and weeding of lettuce to increase yield. Its vision system scrutinizes each plant and then applies "advanced artificial intelligence algorithms that make plant-by-plant decisions" to optimize yield and then eliminate unwanted plants according to its programming.

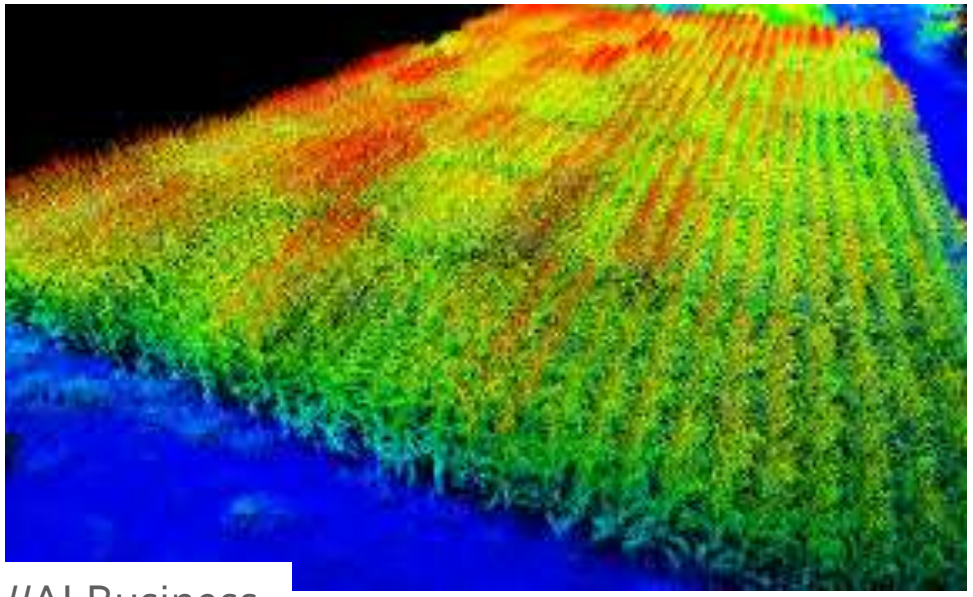
Precision Lettuce Thinning
EFFECT OF USAGE

- **CHARACTERIZE EVERY PLOT** by counting plants and plant spacing, building canopy height distributions, and measuring key physiological parameters
- **GENERATE TABULAR DATA** and statistics for each plot
- **BUILD PLOT IMAGE LIBRARY** that contains all images and plot reconstructions from every plot

Source: Blueriver Technology
http://smartmachines.bluerivert.com/

USE CASE – "Zea"
Early season plant-by-plant phenotypic measurement system

- Zea delivers high-throughput, low-hassle, high-quality plot characterization metrics, with a stand
  count error rate of less than 5% for plants between V2 and V5 (approx. 5-20" tall).



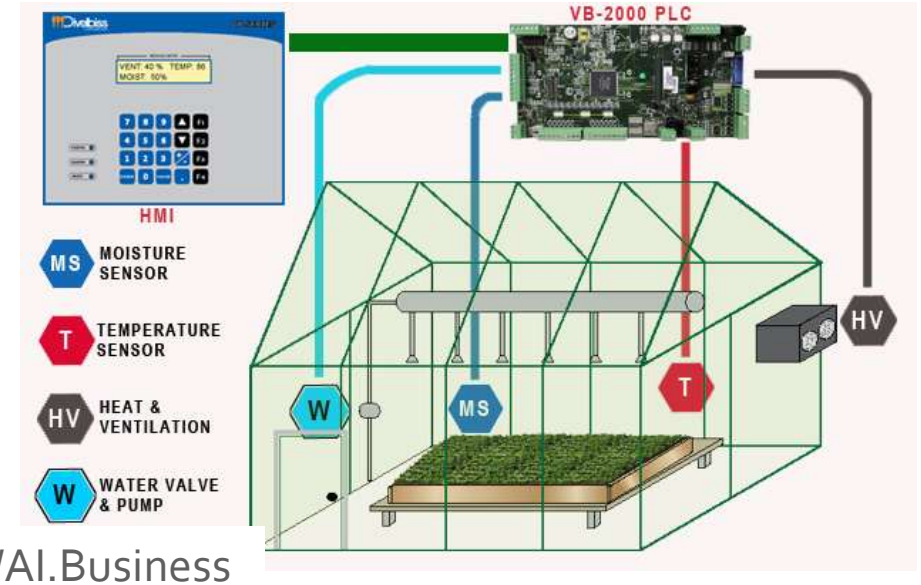
ZEA phenotypic measurement
EFFECT OF USAGE

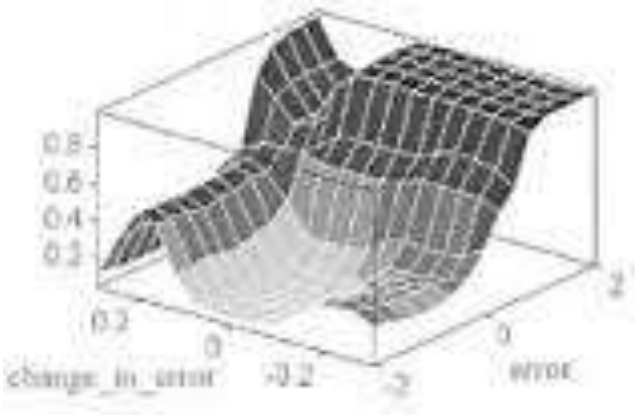
- Ability to do unbiased, consistent measurements of stand count, plant spacing, height, greenness and leaf area, across all of locations, at multiple time points
- Possibility to replace your field crews and all the hidden costs that come with them

Source: Blueriver Technology
http://smartmachines.bluerivert.com/

USE CASE - Synthesis of a Greenhouse Climate Controller using AI-based techniques

- Artificial intelligence system and intelligent control methodologies for the analysis and synthesis of intelligent climate controllers. The system uses Artificial Neural Networks (ANNs) and Fuzzy Logic Controllers (FLCs) for the regulation of climate variables like temperature and humidity in artificially conditioned greenhouses





Greenhouse Climate Controller
EFFECT OF USAGE

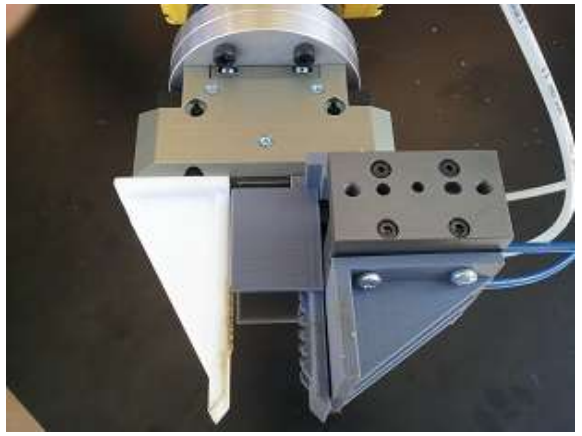
- The work represents a first attempt to apply an AI technique within a greenhouse.
- Due to the physical dynamics involved within a greenhouse the synthesis of a climate controller becomes a complicated task using traditional control techniques.
- Fuzzy Logic represents a useful tool for solving this problem. From experiments carried out, FLC gives the best performances in terms of precision, energy and also robustness.
- Work is still in progress in order to implement a biological model of the plants' growth depending on environment parameters so that it will be possible to automatically establish the best control policy and to compute the optimal values for the set-points. Finally, the economic return could be estimated using a neural network-based forecasting technique.

Source: L. Occhipinti et al.
https://www.researchgate.net/publication/3659496_Synthesis_of_a_greenhouse_climate_controller_using_AI-based_techniques

USE CASE - GIGAS: Guelph Intelligent Greenhouse Automation System

- GIGAS components include a vision system with multiple cameras to take images of the plants.

  At the back end is a plant database that keeps track of all the plants in the greenhouse, with a decision support and planning element, where all the calculations are made. Once a decision is made, that message is sent to the robot that goes and does the job.



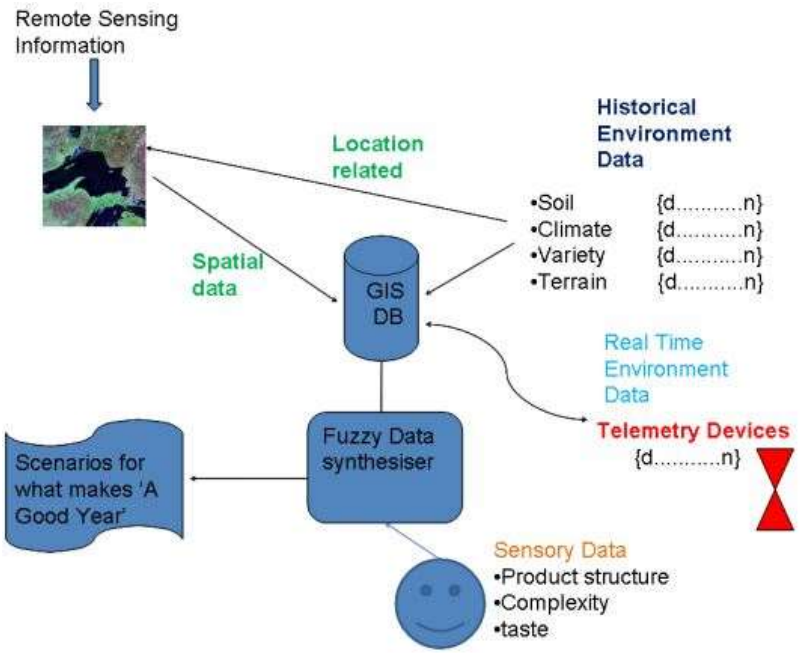
GIGAS
EFFECT OF USAGE

- This robot can gently pick an individual beefsteak tomato, or properly select a tomato cluster for supper. The robot also has a different arm adapted for trimming foliage and de-leafing.
- With this system it is possible to obtain maximum quality yield with best timing of harvest and other operations.

Source: The Robotics Institute of Guelph
http://robotics.uoguelph.ca/node/10

USE CASE - Computational intelligence and geo-informatics in viticulture

- Geo-informatics is a type of artificial intelligence application that combines geodetic and spatial information processing methods with computing hardware and software technologies.
- The system includes modelling the effects of the environment, such as climate, atmosphere, soil type, terrain, minerals, transition metals and irrigation of saline water on the development of rootstock, to crop growth and berry ripening rates, protein conversion in different varieties and their composition, within and among vineyards.



Computational intelligence in viticulture
EFFECT OF USAGE

- Based on the recent developments in viticulture the combination of experimental methods using conventional and contemporary computational techniques, together with a range of field dependent software and hardware components brings valuable data for obtaining quality yield of grapes and high value wines.

Source: Geoinformatics Research Centre, School of Mathematical and Computing Sciences Auckland University of Technology (AUT), New Zealand
http://www.wseas.us/e-library/conferences/2012/Vouliagmeni/ACA/ACA-12.pdf

USE CASE - Driverless Tractors

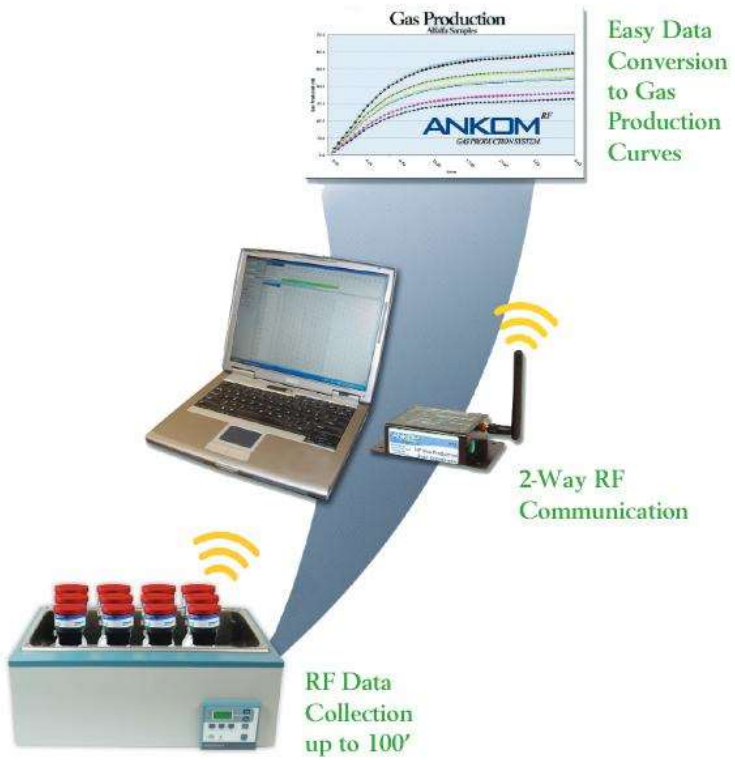
- Using ever-more sophisticated software coupled with off-the-shelf technology including sensors, radar, and GPS, the system allows an operator working a combine to set the course of a driverless tractor pulling a grain cart, position the cart to receive the grain from the combine, and then send the fully loaded cart to be unloaded.

Driverless Tractors
EFFECT OF USAGE

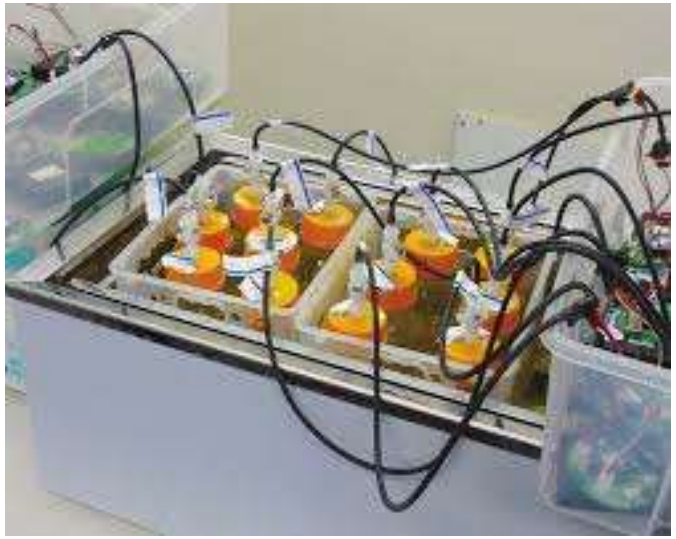
- Possibility to overcome the problem of an inadequate supply of skilled labor during planting and harvesting
- Allow more acreage to be worked for longer time periods
- Higher efficiency for precision agriculture
- Smaller autonomous systems could prove more economical, especially if they work continuously.

Source: http://america.pink/driverless-tractor_1320692.html

USE CASE – Fermentrics: Gas fermentation systems



This system uses artificial intelligence to predict rapidly the outcome of the fermentation process in cattle. It can provide a level of nutritional analysis of a feed in four hours similar to that achieved in 48 hours by conventional methods.



Gas Fermentation System
EFFECT OF USAGE

- The system provides a diagnostic approach to providing qualitative and quantitative data on the rate and extent of carbohydrate digestion by cattle.
- The system allows allow to rapidly predict the outcome of fermentation and isolate the effects of additives in during the fermentation process.
- Knowing what happens to digestion over 48 hours is of great value, add in rates life gets better. One still has a problem in that measured gas levels represent both Co2 and CH_4.

Source: Fermentrics
www.fermentrics.com/

USE CASE - Hortibot robot for weeding

- The Hortibot is about 3-foot-by-3-foot, is self-propelled, and uses global positioning system (GPS). It can recognize 25 different kinds of weeds and eliminate them by using its weed-removing attachments.

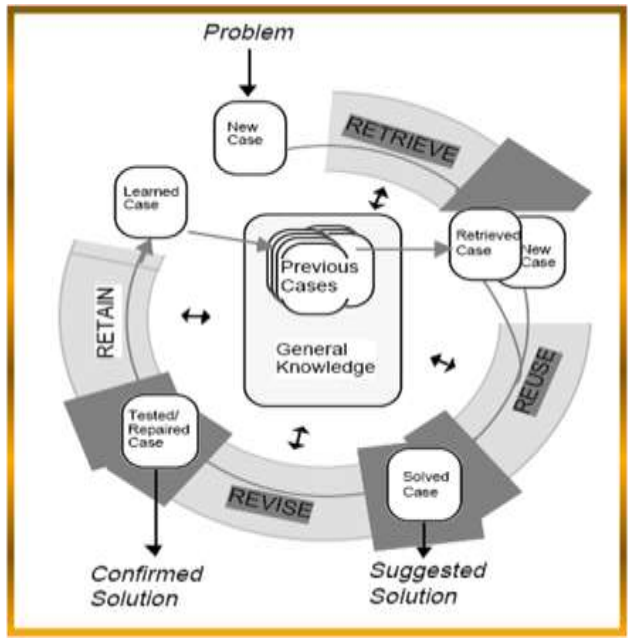
HortiBot
EFFECT OF USAGE

- HortiBot is eco-friendly, because it sprays exactly above the weeds
- As the machine is light -- between 200 and 300 kilograms -- so it will not hurt the soil behind it.
- It is also cheaper than the tools currently used for weed-elimination as it can work during extended periods of time.

Source: http://orgprints.org/11263/1/ASABE_paper_S%C3%B8rensen.pdf

USE CASE – "Glaucus": CBR system for fisheries

- Glaucus is a Case-Based Reasoning (CBR) system which aims to help the fish farmers with their decision making when conduction sorting operations at their aquaculture sites.
- The system also provides data required for proper Fish disease diagnosis and treatment.
- The system is built in Java and uses the jColibri development framework for Case-Based Reasoning. It retrieves cases based on similarity function from myCBR and jColibri in addition to custom made ones.



“Glaucus”: CBR system for fisheries
EFFECT OF USAGE

- Glaucus recognizes the current situation from the case base and uses the outcome/result of that situation to output a risk with the current situation.
- The case base(memory of situations) is composed of real-world situations which we have captured from raw data in an industrial database

Source: Norwegian University of Science and Technology
http://www.diva-portal.org/smash/get/diva2:489216/FULLTEXT01.pdf