Agricultural Robotics from Drones to Wearable Robotics

Human Machine Integration Laboratory

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Agricultural Robotics Market

BIS Research, “Global Agriculture Drones and Robots Market - Analysis and Forecast, 2018-2028”

The global market for agriculture drones and robots is projected to grow from **$2.53 million** in 2018 to **$23.06 billion** by 2028.
The market is expected to witness a CAGR of **24.76%** from 2018 to 2028.

A second report

7.4 billion in 2020 to USD 20.6 billion by 2025; it is expected to grow at a Compound Annual Growth Rate (CAGR) **of 22.8%** from 2020 to 2025.

MACRO DRIVERS

Macro factors are driving agtech adoption

Population Growth

Environmental Cost

Changing Diets

Declining Sensor Costs

Drivers

- Need to apply site-specific farming,
- Variable rate application of raw materials and resources as per requirement
- Decline in agricultural labor across the world.

Robotic Areas

Robotic Device: Senses the environment to collect data, makes decisions, and then acts on the environment

Areas:

1. Precision crop farming,
2. Livestock monitoring,
3. Soil and farm management,
4. Milking robots,
5. Harvesting, picking, and weeding robots,
6. Autonomous robot tractors
7. Seeding robots
8. Pruning robots

New Trends

Robot-as-a-Service (ARaaS) business model is expected to create a massive disruption in the agricultural robots market.

Service business model

Agronomic services:

guidance & steering services, flow & application controls, yield monitoring services, water management services, specialty crops services, and data management services.

Drones

The UAVs or drones segment is estimated to hold the largest share of the agricultural robots market in 2020.

UAVs or drones are used for soil and crop field analysis and livestock management for the past several years. Their robust models are continuously being introduced in the market for pesticide spraying (such as the AGRAS T16 drone from DJI).

Service Market

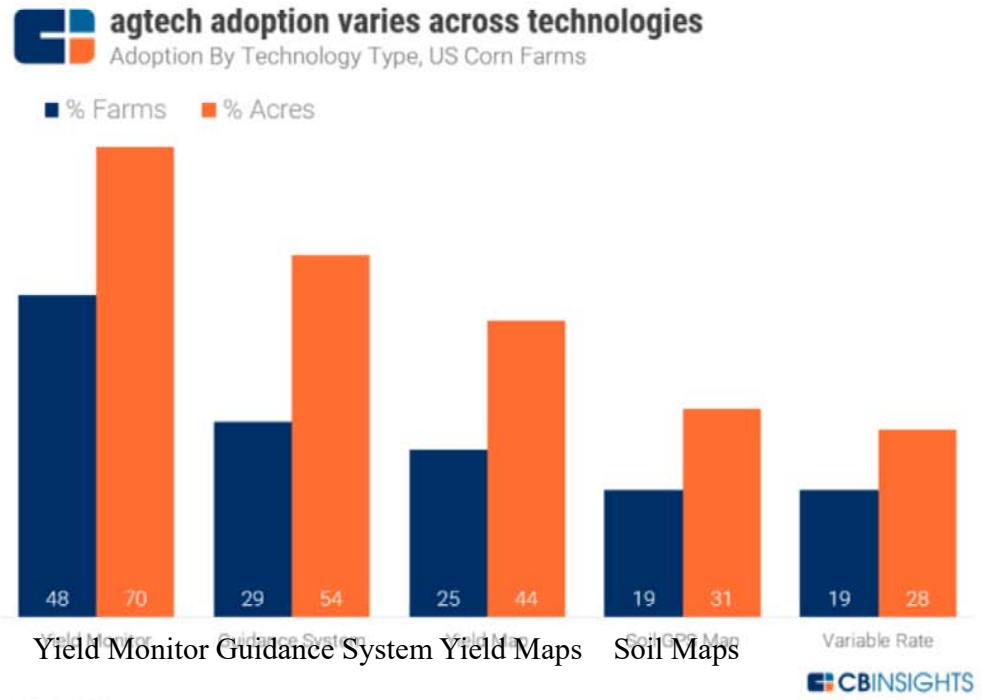
Agricultural robots market based on offering, the services segment of the market is projected to grow at the highest CAGR during the forecast period.

The high costs of agricultural equipment such as driverless tractors, fruit harvesters, and weeding robots have pushed companies to adopt a leasing model (such as Naïo Technologies) to enable farmers to field test robotic equipment to decide if they are a right fit to cater to their requirements.

STATE OF DIGITIZATION

Agtech has traction among U.S. farmers

According to the USDA, agtech is used at varying rates by US farmers, with yield monitoring and guidance systems leading the way.



USDA, 2016

…TECHNOLOGY WILL MAKE MEETING DEMAND POSSIBLE

"In agriculture, everyone agrees that maybe not right away but say in 15 years water will be expensive, healthy soil will be scarce…**Why wait to work on that problem until it's a crisis?**"

First Round

Rob Hayes

Partner, First Round Capital

FINANCING TRENDS

Smart money VCs bet on farm-focused startups

Kleiner Perkins

OF INVESTMENTS:7

- FARMERS BUSINESS NETWORK
- FarmersEdge™

Khosla Ventures

OF INVESTMENTS:4

- BLUE RIVER TECHNOLOGY
- Granular

True Ventures

OF INVESTMENTS:1

- we farm

CBINSIGHTS Source: CB Insights

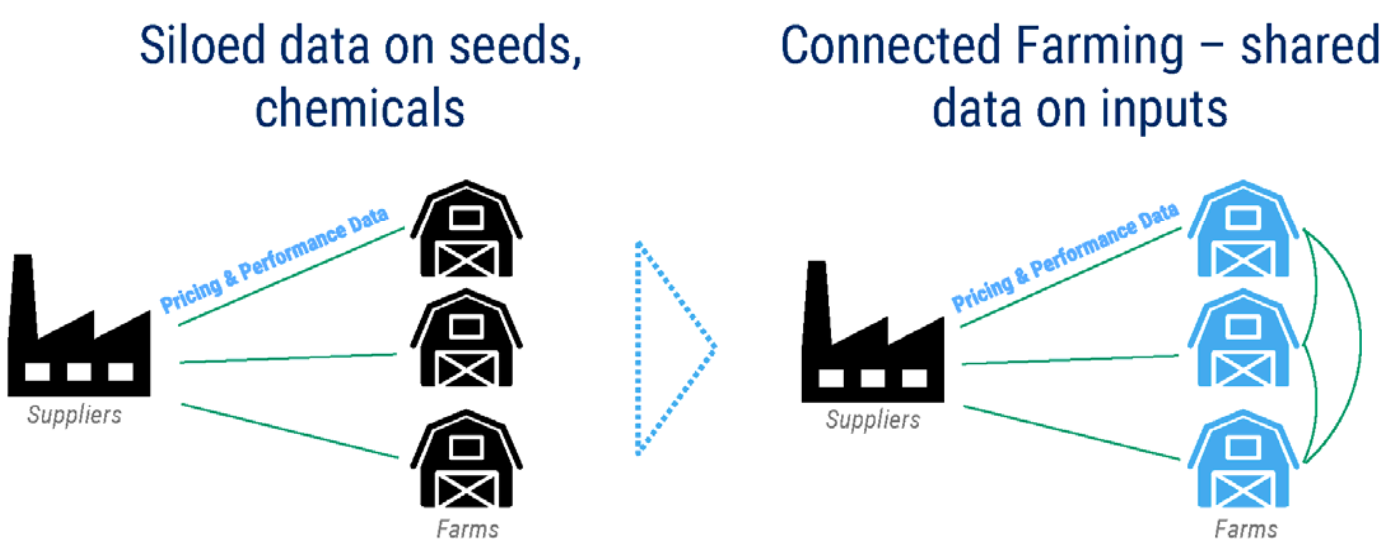
FINANCING TRENDS

Suppliers actively acquire farm-focused startups

Company	Target	Date	Company Type
MONSANTO	HydroBio	05/2017	Analytics
	VitalFields	11/2016	Farm Mgmt.
	Solum	02/2014	Analytics
	Climate Corp.	11/2013	Analytics
syngenta	FarmShots	02/2018	Aerial Imaging
	Ag Connections	10/2015	Farm Mgmt.
JOHN DEERE	Blue River Technology	09/2017	Robotics
	Monosem	11/2015	Machinery
DUPONT	Granular	08/2017	Farm Mgmt.
AgJunction	Novariant	03/2015	Automation

DATA AGGREGATION

Ag suppliers no longer solely control input data



DATA AGGREGATION

Farm networks help farmers harness data

FARMERS BUSINESS NETWORK

Users: 5,000 Farms
Acres Covered: 16M

FBN allows farmers to anonymously share data about everything from seed performance to chemical pricing to help farmers make informed decisions.

FARMOBILE

Users: 700 Farms
Acres Covered: 1.3M

Farmobile makes a sensor that collects agronomic data from farm equipment. This data is stored in the Farmobile platform and can be sold by users.

we farm

Users: 686K Small Farmers
Acres Covered: Undisclosed

WeFarm is a peer-to-peer social network for small, rural farmers in developing countries. The network allows farmers to share data and ask questions over SMS text.

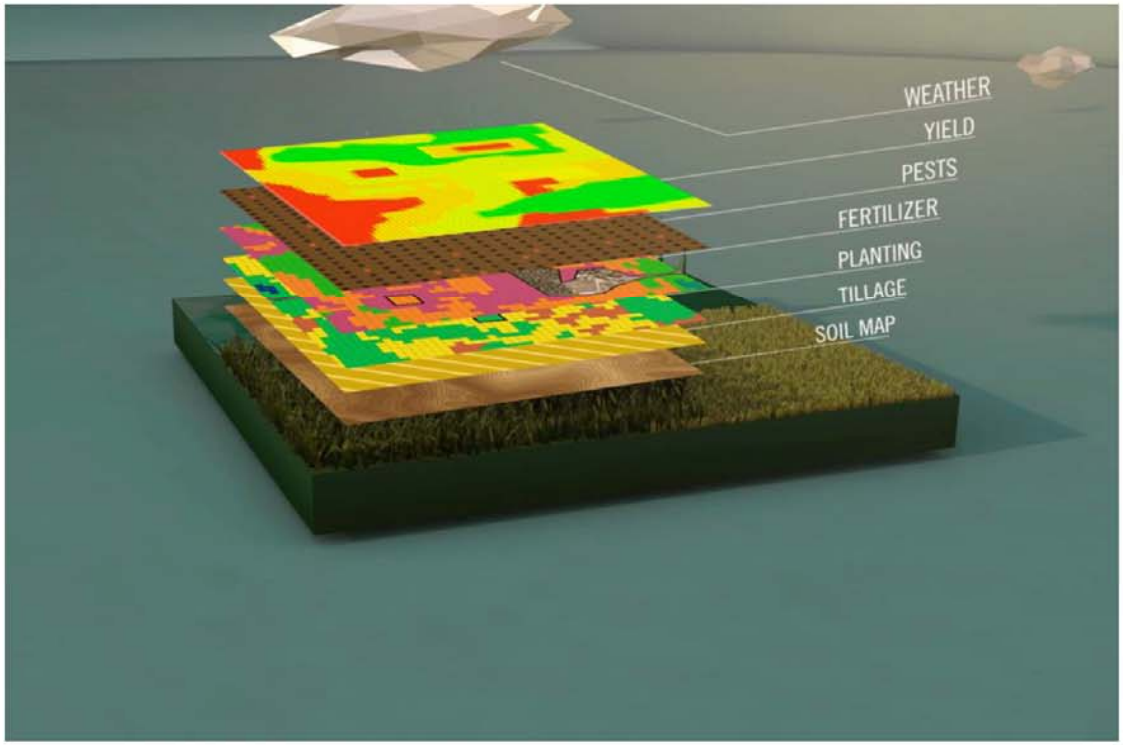
Source: FBN, Climate FieldView, Farmobile

FARMERS BUSINESS NETWORK

FARMERS BUSINESS NETWORK

$180M Disclosed
Equity Funding

FBN allows farmers to anonymously share data about everything from seed performance to chemical pricing to help farmers make informed decisions



Select Investors

Google Ventures	Acre Venture Partners	Kleiner Perkins
Series D	Series B, C, D	Seed, Series A

CBINSIGHTS Source: CB Insights, FBN

FARMOBILE

FARMOBILE

$25M Disclosed
Equity Funding

Farmobile makes an in-cab sensor that collects agronomic data that can be shared with service providers and sold to other farmers.

Farmobile sensor

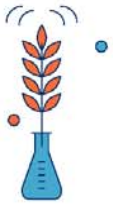
Select Investors

Anterra Capital	**AmTrust**
Series A, B	Series A

CBINSIGHTS Source: CB Insights, Farmobile

EFFICIENCY - SENSORS

Sensors are now common throughout farming



Ground-Based

Farms use sensors to monitor soil and plant health

Aerial Imaging

Aerial imaging captures data on crop yields, plant health, and irrigation needs

Machine-Based

Machine attached sensors capture data on equipment performance and crop conditions

EFFICIENCY - SENSORS

Ground-based sensors provide comprehensive, precise crop data

Plant/Soil Metrics

- Crop health monitoring
- Irrigation management
- Soil health management
- Pest management

cropx

Saturas
Decision Support System for Precision Irrigation

Animal Monitoring

- Animal health
- Fertility
- Herd location

SWINETECH

HerdDogg

Weather Forecasting

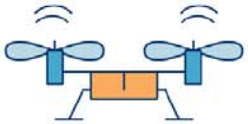
- Weather forecasting
- Moisture sensing

Sencrop

CBINSIGHTS Source: CB Insights

EFFICIENCY - SENSORS

Advanced aerial imaging is now possible



Drones can fly at low speeds and altitude to capture crop data. Startups have focused on developing sensors for drone platforms, rather than the drones themselves.

SLANTRANGE
IMPROVING AGRICULTURE FROM ABOVE

Agribotix

GreenSight
AGRONOMICS

Advances in LIDAR and remote sensing have improved fixed-wing aerial imaging. Traditional aircraft can cover greater distances at higher speeds.

ceres imaging

Satellites can cover huge areas in one image. Hyperspectral imaging has improved the granularity of satellite imaging.

Descartes Labs

FluroSat

swiim

CBINSIGHTS Source: CB Insights

EFFICIENCY - ANALYTICS

Startups are leveraging AI to improve a range of farm decision making

Crop Simulations

Analytics software can be used to model crop growth and environmental simulations. CiBO offers a range of products that simulate complex crop dynamics.

Weather

Weather data can be a powerful tool in farming. Weather Analytics offers analytics software that helps farmers make crop forecasts based on weather conditions.

Farm Ops

Machine learning can help automate and enforce crop growing operations. Prospera uses analytics to optimize irrigation, fertilization, and planting.

A few startups have designed ag-specific drones

Crop Spraying

The DJI Agras MG-1 in action

DJI Innovations, a Shenzhen-based drone company, makes an octocopter drone for chemical spraying

Imaging

American Robotics designed a multipurpose drone for farming

t company!

Buyers: Medical Community and Industrial Community

Sellers: Academics, Small Businesses, Large Companies Component Manufacturers

What are we Hearing:

- Aging Workforce with a limited pool of young people to hire
- Improve the safety of the workforce (reduce healthcare costs)
- Improve worker wellness

Industrial Systems

Wearable robotic systems will assist workers:

a. to lift heavy objects,
b. palletize, and
c. perform tasks with less fatigue.

This growing field is moving from the military super-suits to the industrial and manufacturing workplace.

FORTIS

ShoulderX

Laevo

What is Fueling the Growth of Wearable Robotic Systems?

- Global Demographics
  - Older workforce
- Better robotic systems
  - Batteries, sensors, actuators, microprocessors

Cyberdyne

What is a Wearable Robotic System?

- **Device worn on the body to assist the user**
  - Non-anthropomorphic or Anthropomorphic

RB3D

Ekso Bionics

What is a Wearable Robotic System?

- **Device can be Passive or Active**
  - Passive systems use springs or structures to push or pull on the body
  - Active systems use motor/pneumatics/hydraulics to assist the user in the task. "Put energy into the system"

FORTIS

Panasonic

What is a Wearable Robotic System?

- **Device can assist a joint or transfer the load to the ground**

Cyberdyne

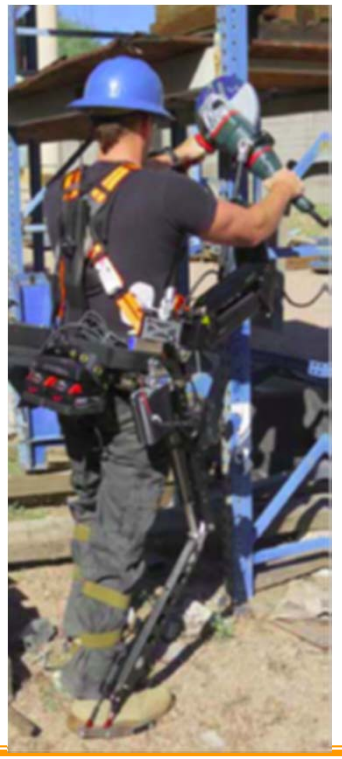
StrongArm

Panasonic

What is a Wearable Robotic System?

- Device can be soft or have a structure
  - Soft systems that conform to the body are more comfortable but rely on the human joints to absorb the reaction loads
  - Systems with structures have mechanical joints to absorb the reaction loads

Harvard



Goals of a Wearable Robotic System

- Seamlessly interact with the user
- Must not disrupt the natural gait cycle or human movement
- Pay for the weight penalty (must reduce metabolic cost)
- Easy to use, must not have to think about it
- Walk faster, lift heavy objects, give an assistance

Challenges

- Most bionic devices are too heavy
  - Increased metabolic cost
  - Large and clunky

- Most bionic devices do not seamlessly interact with the user
  - Impair gait motion
  - Must use tricks or patterns to get them to work
  - Not intuitive
  - Use standard controllers from the robot community

Overcome the Challenges

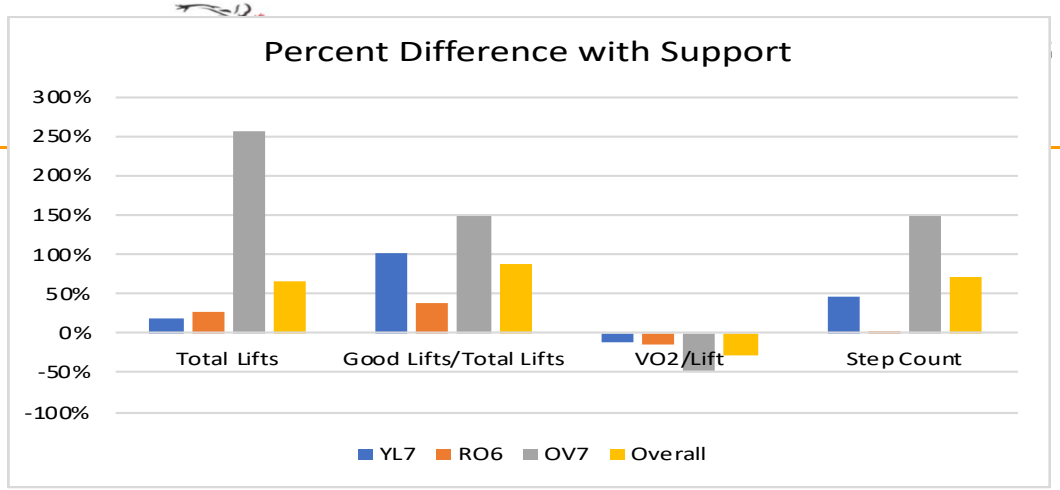
- Store and release energy using springs, pneumatics etc
- Use human based controllers
  - Add positive power to the gait cycle
  - Respond to the user's movement
- Motors, batteries, and microprocessors are cheaper, faster and lighter

Hip Exoskeleton

Device must be:

- Portable
- Lightweight
- Pay for the weight penalty of the device
- Safe

Systems combine soft straps with a motorized joint



Laevo Back Exoskeleton

Assistive

Walking Assist Device, Honda, Japan

Bodyweight Support Assist, Honda, Japan

Power Assist Suit, Kawasaki, Japan

Panasonic, Japan

Innophys, Japan

Hexar Systems, Korea

B-temia Keeogo, Canada

PhaseX AB, Sweden

Manufacturing and Construction

Daewoo, Korea

RB3D, France

Fortis, USA

MAX Exoskeleton, US Bionics

Manufacturing and Construction


Cyberdyne, Lumbar System

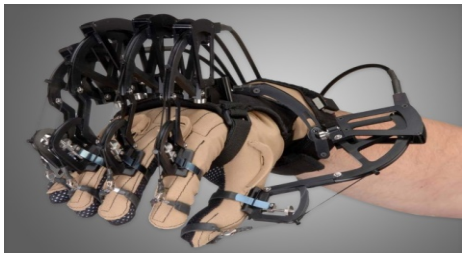
Robomate, Germany

Panasonic, Japan


Arm Exoskeleton,
Stuttgart, Germany

Manufacturing and Construction

Festo, Germany



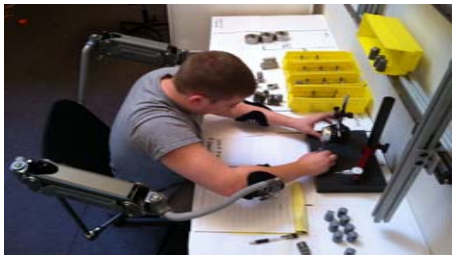
Cybergrasp, USA

Roboglove, Bioservo, USA

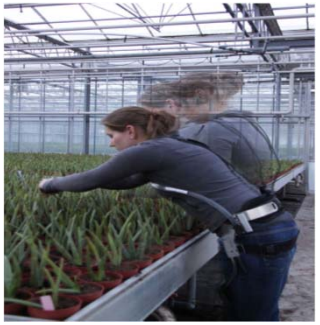
Manufacturing and Construction

Strong Arm, USA

Noonee, Switzerland



X-Ar Equipois Inc. (USA)



Laevo, NL

Conclusion

- Wearable systems can assist the upper body and lower limbs
- Systems are being developed that are passive or active
- Systems must be comfortable, easy to use, and pay for the weight penalty
- More information can be found at: http://www.wearablerobotics.com