Γεωργία Ακριβείας & Παρακολούθηση Φυσικού Περιβάλλοντος

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Εργαστήριο Τηλεπισκόπησης Εθνικό Μετσόβιο Πολυτεχνείο
Market numbers

✓ global UAV market is expected to grow at a 10% CAGR up to 2020
Market

4x Heron ..550 hours of surveillance per month

numbers

✓ 10x ... $400 million

Israel - India
70 Drone Companies To Watch in 2016

UAV Coach
Market

Agriculture drones market $3.6 Billion by 2022
[Market Watch, 2016]

Non-military applications $6 Billion by 2020
[Markets & Markets, 2015]

Global UAV Market from $10 Billion in 2015 to $15 Billion by 2020

Road Map to Growth
- Popularity of Drone-as-a-Service
- Adoption of Photography Drones
- Use of Drones for High-Risk Tasks
- Demand for Commercial Aerial Surveys
- Use of Multirotor Drones for Law Enforcement
- Demand for Rotary Blade UAVs for Aerial Filming

Key Players
- Parrot SA
- 3D Robotics, Inc.
- CyPhy Works, Inc.
- Piorita Robotics, Inc.
- SZ DJI Technology Co. (DJI)

Control of the Skies
US Market Share by FAA registration, June 2015

DJI 48.4%
Lepton 2.4%
AeroVironment 12.1%
3D Robotics 7.6%
PrecisionHawk 3.9%
Other 25.5%
<table>
<thead>
<tr>
<th>Company</th>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lily Robotics Inc.</td>
<td>Hardware</td>
<td>$5,0M</td>
</tr>
<tr>
<td>SkyWard</td>
<td>Software</td>
<td>$5,8M</td>
</tr>
<tr>
<td>Squadrone System</td>
<td>Hardware</td>
<td>$4,3M</td>
</tr>
<tr>
<td>Helico Aerospace</td>
<td>Hardware</td>
<td>$3,9M</td>
</tr>
<tr>
<td>Matternet</td>
<td>Hardware/Software</td>
<td>$3,5M</td>
</tr>
<tr>
<td>Extreme Fliers</td>
<td>Hardware</td>
<td>$3,2M</td>
</tr>
<tr>
<td>Skydio</td>
<td>Software/Service</td>
<td>$3,0M</td>
</tr>
<tr>
<td>Dedrone</td>
<td>Software</td>
<td>$2,9M</td>
</tr>
<tr>
<td>RedBird</td>
<td>Software</td>
<td>$2,8M</td>
</tr>
<tr>
<td>Dronomy</td>
<td>Hardware</td>
<td>$1,5M</td>
</tr>
<tr>
<td>OnagoFLy</td>
<td>Hardware</td>
<td>$1,4M</td>
</tr>
<tr>
<td>Fotokite</td>
<td>Hardware</td>
<td>$1,3M</td>
</tr>
<tr>
<td>Prenav</td>
<td>Hardware/Services</td>
<td>$1,2M</td>
</tr>
<tr>
<td>Airdroids</td>
<td>Hardware</td>
<td>$929,2K</td>
</tr>
<tr>
<td>Powerup Toys</td>
<td>Hardware</td>
<td>$492,8K</td>
</tr>
<tr>
<td>Ascent AeroSystems</td>
<td>Hardware</td>
<td>$406,1K</td>
</tr>
<tr>
<td>Skyworks Aerial Sys.</td>
<td>Hardware/Software</td>
<td>$335,0K</td>
</tr>
<tr>
<td>Splash Drone</td>
<td>Hardware</td>
<td>$303,4K</td>
</tr>
<tr>
<td>Fleye</td>
<td>Hardware</td>
<td>$281,8K</td>
</tr>
<tr>
<td>Krossblade Aerosp.</td>
<td>Hardware</td>
<td>$230,8K</td>
</tr>
</tbody>
</table>

**Market**

- SkyTech London, UK
- RPAS CIVOPS 2016 Brussels, Belgium
- TUSExpo The Hague, Netherlands
- Drone Days Brussels, Belgium
- Dronemasters Summit@CeBIT Hannover, Germany
- AUVSI's Unmanned Systems Europe 2016 Brussels, Belgium
- Drone Expo Dublin, Ireland
- EuropaDrone Lyon, France
- European UAV Traffic Management Day Geneva, Switzerland
- Drone Convention 2016 Genk, Belgium
- DroneFest Toulouse, France
- Unmanned Solutions Forum Bucharest, Romania
- Roma Drone Conference Rome, Italy
- Drone Expo Greece Athens, Greece
- Nordic UAS Event Odense, Denmark
- UAV Remote Sensing Applications Course Barcelona, Spain
- Unmanned Global Systems Paris-Nord/Villette, France
- RPAS Conference 2016 Brussels, Belgium
- UK Drone Show At Farnborough International Airshow Farnborough, UK
- Drone Experience Nantes, France
- UA Sympex Hamburg, Germany
- ExpoDrone Zaragoza, Spain
- Dronemasters Logistics Hannover, Germany
- Domitaly Milan, Italy
- RAE5 Annual Conference London, UK
- InterAerial Solutions Hamburg, Germany
- DroneTech Torun, Poland
- UAV Show France Bordeaux, France
- Drone Berlin Berlin, Germany
- OverHead Prague, Czech Republic
- Commercial UAV Show London, UK
- Drones Data X Conference – Ireland Dublin/Westport, Ireland
- Catalonia Smart Drone Event Barcelona, Spain
- UK Drone Show Birmingham, UK

- USA: $10,6M
- EU: $41,4M
- Others: $1,5M
Precision Agriculture.. why?
Precision Agriculture: why?

World consumption of major field crops is projected to increase through 2050.

**Source:** USDA, Economic Research Service (reference scenario)

- **69%** Required increase in food calories to feed 9.6 billion people by 2050.
- **28%** Global population directly or indirectly employed by agriculture.

**CLOSING THE FOOD GAP**

**SUPPORTING ECONOMIC DEVELOPMENT**

**REDUCING ENVIRONMENTAL IMPACT**

- **24%** Global greenhouse gas emissions from agriculture and land use change.
Precision Agriculture

- Crop Management
- Selective Harvesting
Precision Agriculture

- Crop Management
- Selective Harvesting

- Platforms (drone, fixed-wing)
- Sensors (RGB, Multispectral, etc)
- Application (Viticulture, Horticulture, etc)
Precision Agriculture

Platforms

- Drones
- Fixed-wing
Precision Agriculture

Platforms

- Drones
- Fixed-wing
Precision Agriculture

Platforms

- Drones
- Fixed-wing
Precision Agriculture
Platforms

- Drones
- Fixed-wing
Precision Agriculture

Platforms

- Drones
- Fixed-wing
Precision Agriculture

- Crop Management
- Selective Harvesting
Reflectance
Precision Agriculture

Sensors

- Multispectral
- Hyperspectral
- Thermal

![Absorbance spectra of different pigments](image)

- Chlorophyll a
- Chlorophyll b
- Carotenoids
- Beta-carotene
- Fucoxanthin
- Phycoerythrin
- Phycocyanin
- Allophycocyanin

![Leaf images with varying severities](image)
Sensors

- RGB
- Multispectral
- Hyperspectral
- SWIR
- ...
Precision Agriculture

Sensors

<table>
<thead>
<tr>
<th>Wavelength (mm)</th>
<th>Effect on Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV</td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>Significantly reduces quantum yield and rate of photosynthesis.</td>
</tr>
<tr>
<td>315~400</td>
<td>Promotes pigmentation, thickens plant leaves, and may be used to prevent harmful insects.</td>
</tr>
<tr>
<td>440~470</td>
<td>Chlorophyll absorption peaks at 439mm and 469mm. The blue spectrum is the most efficiently absorbed spectrum, promoting mainly vegetative growth.</td>
</tr>
<tr>
<td>Visible Spectrum</td>
<td></td>
</tr>
<tr>
<td>510</td>
<td>Quantum absorption in the green spectrum. Little absorption is the yellow spectrum.</td>
</tr>
<tr>
<td>610</td>
<td>No chlorophyll benefit. Efficiently absorbed by algae phycoerythrin and phycocyanin receptors.</td>
</tr>
<tr>
<td>640~660</td>
<td>Chlorophyll absorption peaks at 642mm and 667mm. 660mm is the most vital wavelength for flowering. Speeds up seed germination and flower/bed onset.</td>
</tr>
<tr>
<td>Infrared</td>
<td></td>
</tr>
<tr>
<td>740</td>
<td>Emerson Enhancement Effect - quantum yield of red light and far red light, when shone simultaneously on a plant, increases the rate of photosynthesis.</td>
</tr>
<tr>
<td>1000~1400</td>
<td>No plant activity detected at this wavelength. Heat generated.</td>
</tr>
</tbody>
</table>

- **RGB**
- **Multispectral**
- **Hyperspectral**
- **SWIR**
Precision Agriculture

Sensors

- RGB
- Multispectral
- Hyperspectral
- SWIR
- …
Precision Agriculture

Sensors

- RGB
- Multispectral
- Hyperspectral
- Thermal
- ...

Chlorophyll a
Chlorophyll b
Carotenoids

Wavelength of light (nm) and color

Pixel spectrum

240 bands

Radiance

Wavelength
Precision Agriculture

Sensors

- RGB
- Multispectral
- Hyperspectral
- Thermal
- ...

Headwall Photonics, imec, Ximea, 3D-ONE, FLIR, Xenics, Infrared Solutions
NDVI color-maps..

- RGB
- Multispectral
- Hyperspectral
- Thermal
- ...

Sensors
RELATIONSHIPS BETWEEN NDVI, CANOPY STRUCTURE, AND PHOTOSYNTHESIS IN THREE CALIFORNIAN VEGETATION TYPES

John A. Gamon, Christopher B. Field, Michael L. Goulden, Kevin L. Griffin, Anne E. Hartley, Geeske Joel, Josep Peñuelas, and Riccardo Valentini

Carnegie Institution of Washington. Department of Plant Biology, Stanford, California 94305 USA

Abstract. In a range of plant species from three Californian vegetation types, we examined the widely used “normalized difference vegetation index” (NDVI) and “simple ratio” (SR) as indicators of canopy structure, light absorption, and photosynthetic activity. These indices, which are derived from canopy reflectance in the red and near-infrared wavebands, highlighted phenological differences between evergreen and deciduous canopies. Indicators of nutrient status, however, due to the varying abundance of
NDVI color-maps.

Sensors

Απορροφούμενη Φωτοσυνθετικά Ενεργή Ακτινοβολία

FAPAR

Δείκτης Φυλλικής Επιφάνειας

LAI

Remote estimation of canopy chlorophyll content in crops
Anatoly A. Gitelson, 1,2 Andrés Viña, 1 Verónica Ciganda, 1,3 Donald C. Rundquist, 1,2 and Timothy J. Arkebauer 4
Received 10 February 2005; revised 15 March 2005; accepted 30 March 2005; published 22 April 2005.

[1] Accurate estimation of spatially distributed chlorophyll content (Chl) in crops is of great importance for regional and global studies of carbon balance and responses to climate change and global warming. In this paper a recently applied for remotely applied for remotely...
Reflectance

- RGB
- Multispectral
- Hyperspectral
- Thermal
- …
Near Infrared 8%  Visible red 50%

Near Infrared 30%  Visible red 40%

\[
\left( \frac{0.50 - 0.08}{0.50 + 0.08} \right) = 0.72
\]

\[
\left( \frac{0.4 - 0.3}{0.4 + 0.3} \right) = 0.14
\]

Healthy

Unhealthy
Reflectance \( / \text{xrhombus} \) RGB \( / \text{xrhombus} \) Multispectral \( / \text{xrhombus} \) Hyperspectral \( / \text{xrhombus} \) Thermal \( / \text{xrhombus} \) …
Reflectance

**Landsat 8**
- 29 July 2014

**RapidEye**
- 17 Aug 2014

**Landsat 8**
- 4 Oct 2015

**Sentinel-2**
- 26 Dec 2015

**Combined Time Series for NDVI**

![Graph](Image)
Precision Agriculture
Leaf Area Index
($m^2$)
Διαχρονική Παρακολούθηση

✓ Δορυφορικά Τηλεπισκοπικά Πολυφασματικά Δεδομένα
✓ Μη Επανδρωμένα Εναέρια Οχήματα
✓ Υπερφασματικά Δεδομένα Πεδίου
✓ Δειγματοληψίες Σταφυλιού
✓ Εργαστηριακές Αναλύσεις
Λήψη Βέλτιστων Αποφάσεων

Έγκαιρη & Έγκυρη Διάγνωση
Λήψη Ορθολογικών Αποφάσεων

✔ Συνδυασμός μακροχρόνιας Γνώσης και Εμπειρίας με Δεδομένα:
✔ Παρακολούθησης
✔ Μετεωρολογικά, Κλιματικά, Εδαφολογικά
✔ Ανάλυση Ανά Ποικιλία, Ανά Αμπελοτεμάχιο
Environmental Monitoring

low-cost sensors
low-weight
Environmental Monitoring

low-cost sensors
low-weight
Environmental Monitoring
Environmental Monitoring
Environmental Monitoring
Environmental Monitoring
Environmental Monitoring

Χαρτογράφηση Φυσικής Αναγέννησης σε καμένες εκτάσεις
Εκτίμηση Καύσιμης Ύλης
Environmental Monitoring

Χαρτογράφηση και διαχωρισμός ειδών βλάστησης
Ερημοποίηση, κοκ
Environmental Monitoring
Environmental Monitoring
Precision Agriculture

- Crop Management
- Selective Harvesting


Kandylakis & Karantzalos, 2016. Precision viticulture from multitemporal, multispectral very high resolution satellite data, ISPRS Archives.

Kalisperakis et al., 2015. Leaf area index estimation in vineyards from UAV hyperspectral data, 2D image mosaics and 3D canopy surface models, ISPRS UAV-g

Karakizi et al., 2015. Spectral Discrimination and Reflectance Properties of Various Vine Varieties from Satellite, UAV and Proximate Sensors, ISPRS Archives

...


Karakizi et al., 2013. Vineyard Detection and Vine Variety Discrimination from Satellite Data, ECPA [1st prize, best poster communication award]