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FEGGA Conference 2019

February 19 – 22, 2019

Drones – Opportunities for Greenkeepers

Using drone technology to assist in making better turf management decisions.

Erich Steiner MSc, Golf Course Architect EIGCA and Landscape Architect FH BSLA

Roland Berger, Computer Engineer FH

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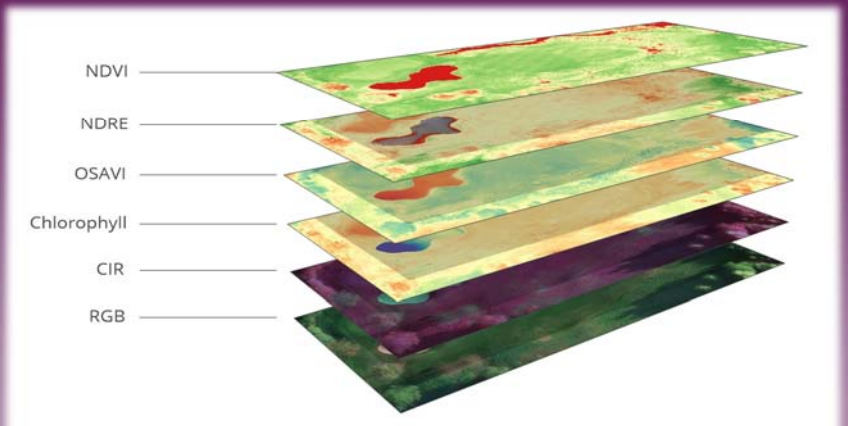
Flying robots are changing our perspective:
hidden things come to light, correlations become clear!



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Our Theme

- **Why** Drones?
- What already **exists**
- What we can **discover** and
- Where are we **going**!

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But first of all, what are the big issues at the moment...

- **climate Change** including national and global influences
- **biodiversity** and unstoppable **Loss of Species** (conservation and creation of habitats)
- **sustainable use** of all **natural resources** (water quality and availability, drainage, etc.)
- use of **plant protection products** (pesticides)
- **soil protection**
- **waste management** (reduce, reuse and recycle)
- **energy efficiency**
- **the digital revolution 4.0**

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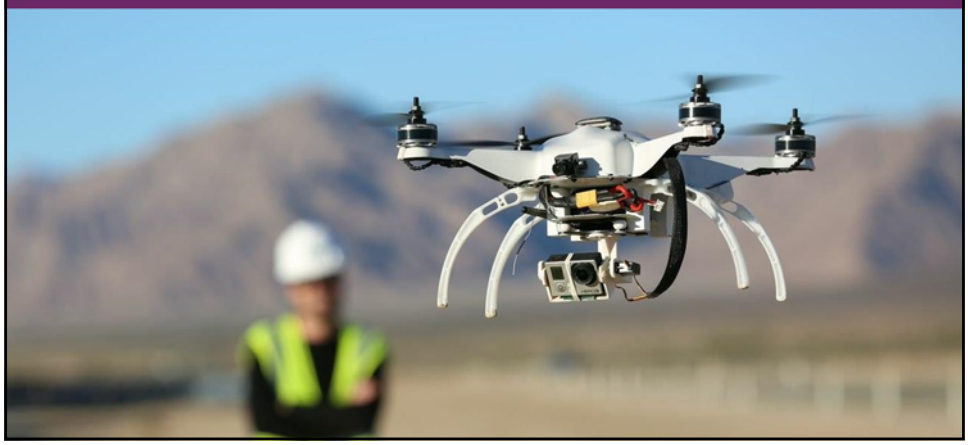
Using drones in golf course construction and turf maintenance



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Flying with Drones

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Flying Robots / Drones

- Winged Drones
- Multicopters
- 300 g .. 25 kg (and more)
- 500 to 50'000 CHF

- Beware the restrictions in your country

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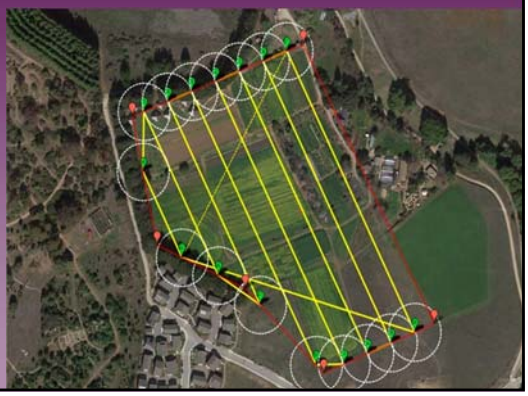
What can we already do with drones: Digital Inventory Survey

- flying, geo-referencing
- processing
- delivering:
  - 3D-Model
  - orthophoto
  - topographic model
  - calculations

Digital Inventory Survey - Advantages

- fast, cheap and complete measurements
- efficient production of base plan information
- provides dimensions
- before and after construction comparisons
- 2D and 3D, high precision (to within a few cm)
- more than just data – visual and measurable



Digital Inventory Survey– Costs and Time Factor

Accept Survey
1- 2 days

Data Collection & Post-processing
1- 2 weeks

Delivery of PDF, CAD File, Contour Map
1-2 weeks

Total Time
2-3 weeks

Mobilize to Site
1 days

Fly Drone & Collect Data
1-2 days

Delivery of PDF, CAD File, Ortho Map, Contour Map, Point Cloud
1-2 days

Total Time
1-4 days

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Quality Aerial Photographs

- Quality images from above…or from the side

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Orthophotos

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3D Modelling from any angle

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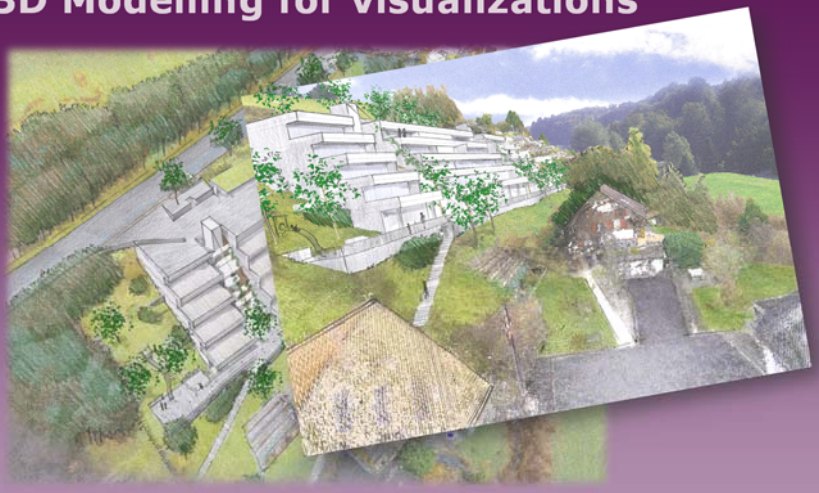
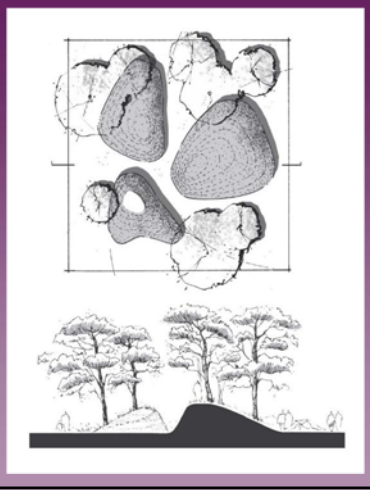
3D Modelling for visualizations

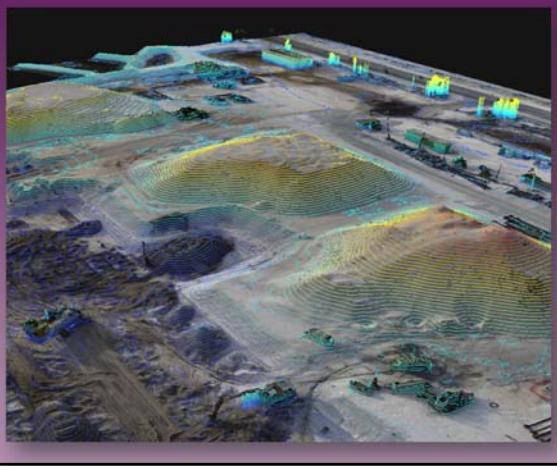


3D Modelling for surveying



Topographic Model

- for contour plans
- for comparison and calculations
- for hydraulic engineering (slopes)



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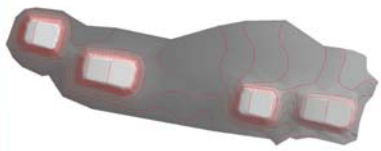
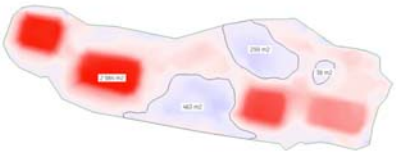
Topographic Model

Example: Cut and fill calculations

Teilbereich 2 – Tees Spielbahn 1



SOLL-Modell



Auftrag (rot) / Abtrag (blau)

Name	Volumendifferenz			Fläche			Bemerkungen
	Auftrag	Abtrag	Bilanz	Perimeter	Auftrag	Abtrag	
TB 2	706 m³	38 m³	+ 668 m³	3'786 m²	2'984 m²	800 m²	Kleinstflächen ignoriert

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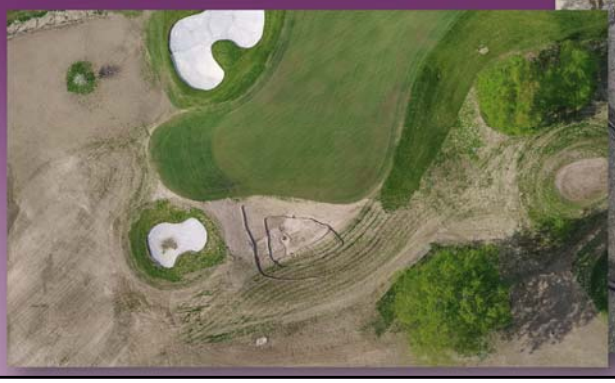
Important information for maintenance

- map drainage lines
- document original seeded surfaces



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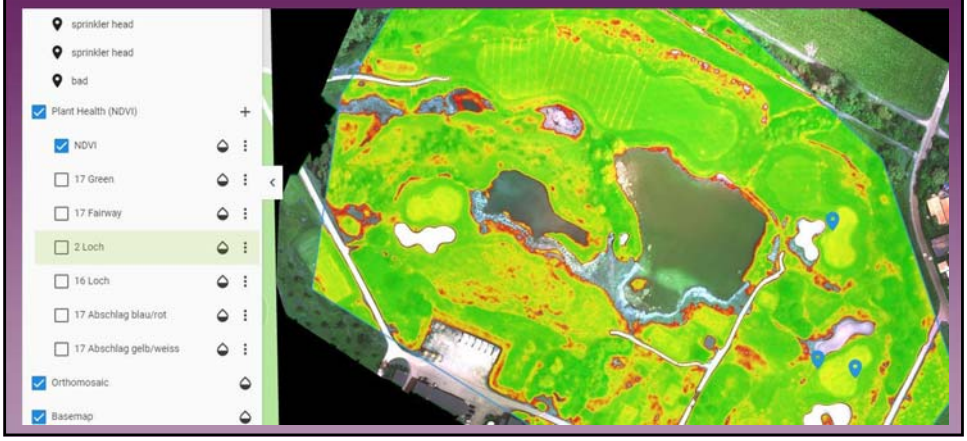
Now let's take the opportunity to look at golf course surfaces in a different way!



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Background Information

- Exploring the earth with satellites
  - RapidEye (ESA 3rd party Mission)
    - 5 Satellites
    - Start 2008
    - 5 spectral bands
  - Sentinel 2 (ESA)
    - 2 Satellites
    - Land monitoring
    - Start Sentinel 2A 2015, Start Sentinel 2B 2017
    - 13 spectral bands
- Reflection and absorption of electromagnetic waves in plants
- NDVI, NDRE, ….

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Special Sensors

- Multispectral
- Hyperspectral
- IR

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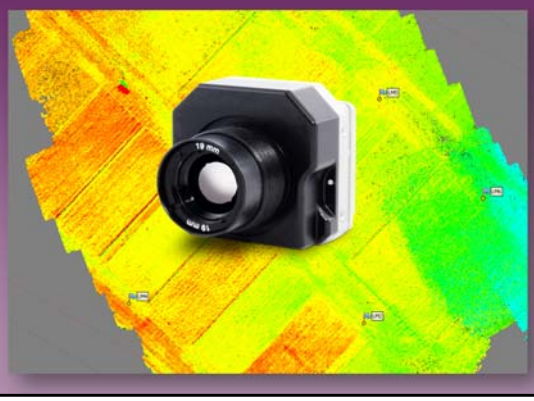
Infrared

- aka thermal imaging
- sensors / resolution
- IR-mapping



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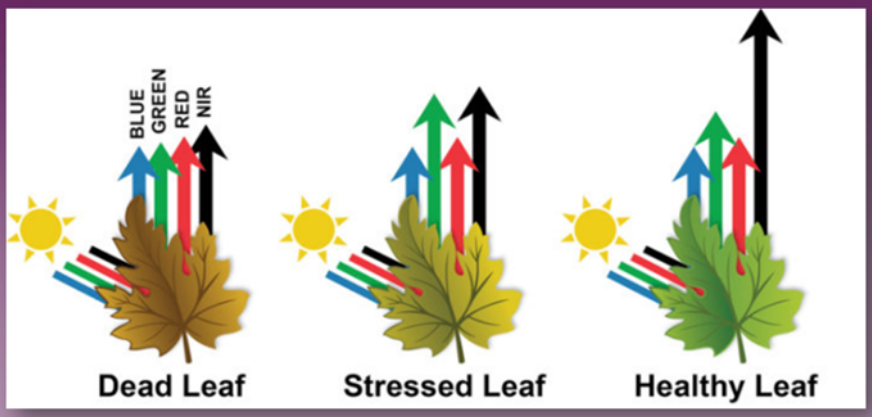
Indexes: NDVI, NDRE, CIR, ...

E.g. Normalized Difference Vegetation Index



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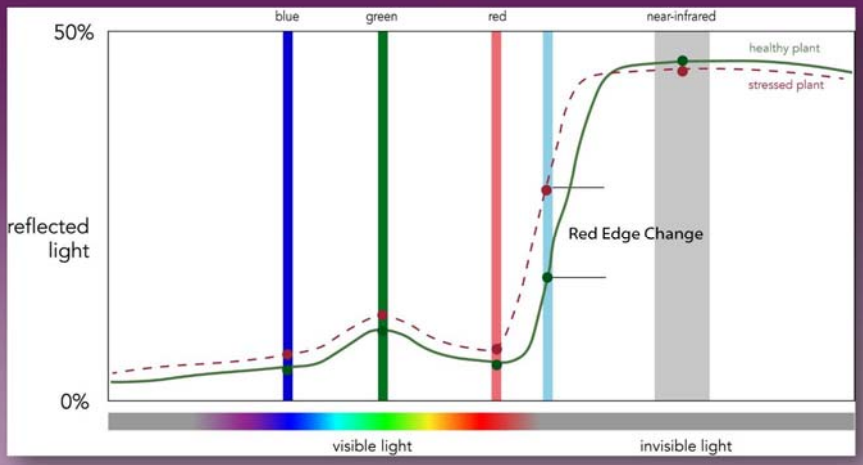
Reflection of Chlorophyll in Plants



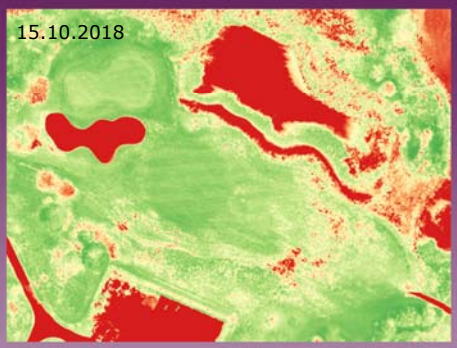
Use of specials sensors in agronomy

- The future for agriculture? **No, the present!**
- What can we already do? What is not yet possible?
- What can be brought to turf management?

Close cooperation with:
- Jörg Morhard, Professor and Turfgrass Specialist (University Hohenheim, Stuttgart)
- Charles Peacock, Professor and Turfgrass Specialist (North Carolina State University)

NDVI (Normalized Difference Vegetation Index)

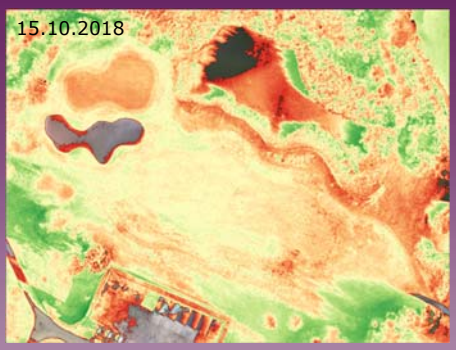
- plant vigor
- differences in soil water availability (in topsoil)
- foliar nutrient content (when water is not limiting)
- yield potential
- percent of coverage



NDVI is effective for indicating plant vigor, distinguishing vegetation from soil and comparing the plant coverage and health over time. Darker green shows the most vigor.

NDRE (Normalized Difference Red Edge)

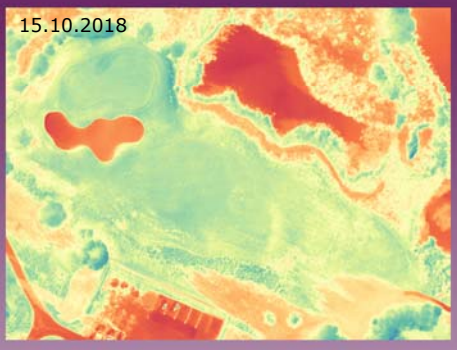
- leaf chlorophyll content
- plant vigor
- stress detection
- fertilizer demand
- nitrogen uptake



NDRE values here show different fertilizer requirements on the golf course. In this index, red areas show areas probably needing more fertilizer.

OSAVI (Optimized Soil-Adjusted Vegetation Index)

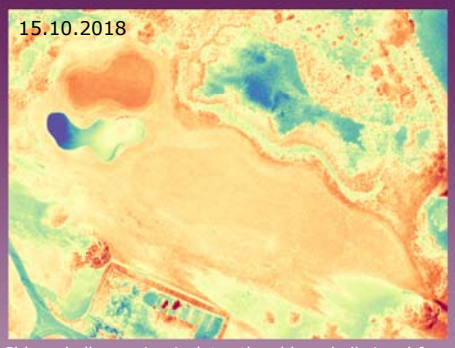
- differentiate soil pixels
- related to LAI (Leaf Area Index, **ground coverage**) at some levels where NDVI saturates
- accounts for non-linear interactions of light between soil and vegetation
- used as a structural index for chlorophyll detection



OSAVI values map variability in canopy density, best used in areas with relatively sparse vegetation. Here we can see the yellow to red areas indicate less plant density.

Chlorophyll Map

- detect chlorotic crops
- plant stress detection
- identify vigorous, healthy crops
- estimate chlorophyll content
- estimate N content (if you know that N is limiting)



Chlorophyll mapping isolates the chlorophyll signal from variability in leaf area and considers the relationship between canopy cover and canopy nutrient content.

CIR Composite (Color Infrared)

- assessing plant health
- identifying plant species?
- identify water bodies
- variability in soil moisture
- assessing soil composition

CIR combines NIR, Red and Green bands which highlights plant health and water bodies. Here the darker red indicates healthier plants, washed out pink indicates stress.

Summary of what can be measured...

- **plant vitality** and health (plant stress, early detection and course of disease)
- **yield** measurements in agriculture
- **chlorophyll** levels in leaf
- nitrogen and phosphorus in leaf (**Nutrient demand** and uptake)
- **moisture** levels in leaf
- water available to plants, **soil moisture**, wet areas, etc.
- composition of the **soil structure**

However, everything still has to be controlled on the ground. The measurements tell us that something is wrong with the plant**...**
but not yet what.

Our Vision: Early identification and documentation of maintenance problems

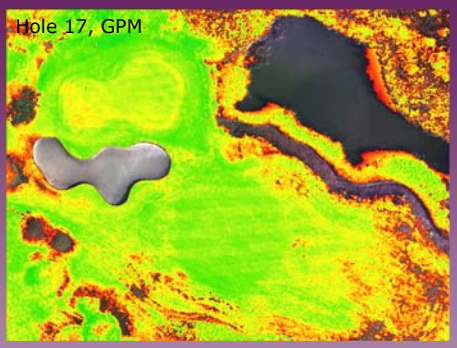
- monitoring of insect, weed and disease outbreaks
- soil moisture analyses
- detecting nutrient deficiency
- measuring the temperature of the turf surface

The primary goal of monitoring with drones and cameras is the **analysis of plant health**. Through a combination of sensors and indexes it should be possible to **detect diseases and deficiencies early**...

Then we have the opportunity to be proactive and **strengthen the plant** instead of being reactive using pesticides.

Case Study 1: Irrigation Audits

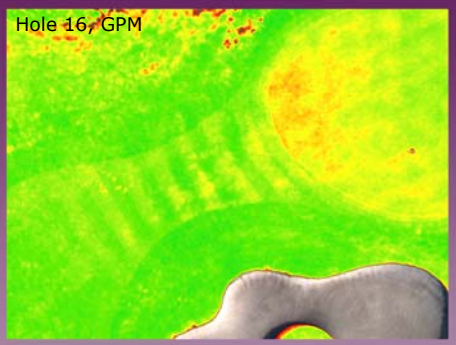
- sustainable water management (surface area and cost optimisation)
- detection of irrigation problems
- monitor sprinkler performance and settings from flight to flight
- early detection of punctual irrigation failure (drought stress)



NDVI evaluation shows inadequate/irregular overlap of irrigation.

Case Study 2: Plant Health and Stress

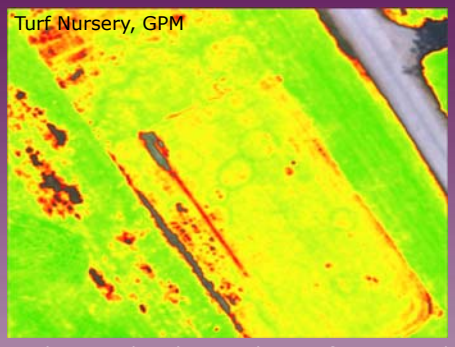
- aerial photographs and analyses have two distinct advantages: multispectral analysis and bird's eye view
- multi-spectral sensors can analyze aerial images and identify problem areas before they can be captured by the human eye



NDVI evaluation shows weak vitality of the turf in the approach area.

Case Study 3: Plant Diseases

- a healthy plant population is continuously endangered by various factors
- with the help of specialized multispectral algorithms, plant diseases can be isolated, monitored and treated early



Multispectral evaluation shows infestation with Fairy Rings (*Basidiomycetes*).

Data is great, but…

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Access, analyse and share the same data via the browser

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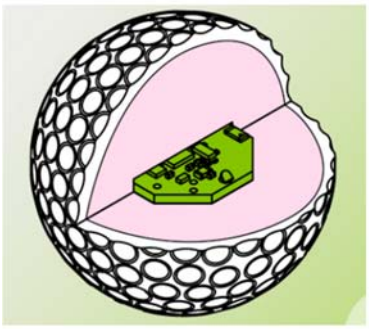
What does the future bring for golf?

What does the future bring for golf?

www.chip-ing.com



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Linking data

- Data provided by the greenkeeper and golf club
- Data collected by the golfer

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All of this may sound frightening today, but it will certainly come and offer us all new challenges and opportunities.

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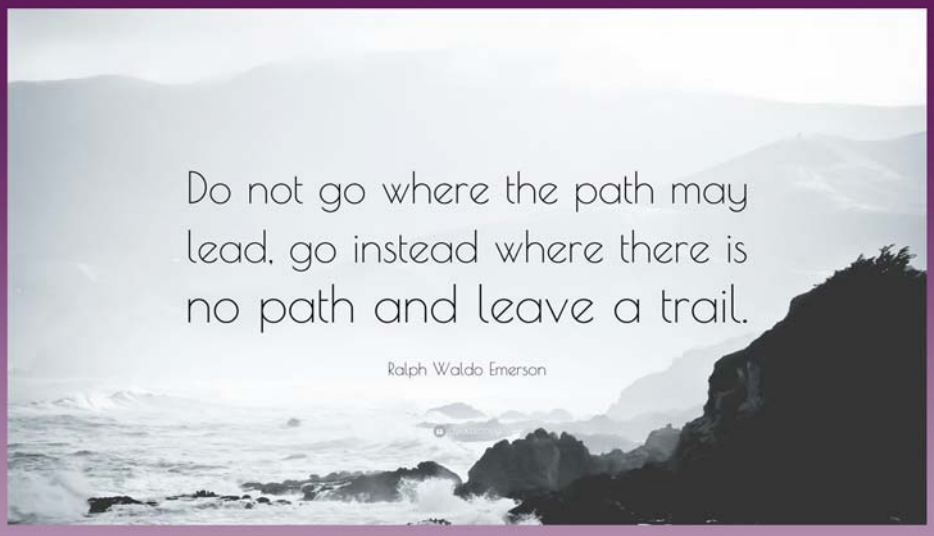

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...Questions and Answers!