FIELDimageR: A tool to analyze orthomosaic images from agricultural field trials in R

This tutorial gives a compilation of functions in statistical information image from field research trials. It uses the package FIELDimageR that allows to copy the image into the computer, crop the image, remove soil, remove shadows, remove other objects, calculate vegetation indices, calculate the canopy cover, count the number of objects, extract color, count pixel values, and much more.

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Introduction

FIELDimageR is an extension of the EBImage package. EBImage offers the implements already installed by using the BioConductor repository.

Installation

FIELDimageR is an extension of the EBImage package. EBImage offers the implements already installed by using the BioConductor repository.

```
BiocManager::install("EBImage")
```

Once we have installed EBImage we can install FIELDimageR from GitHub repository, you need to install the following packages:

```
devtools
raster
sp
spdep
spatial
gtools
gtools
sandwich
multcomp
```

```
install.packages("devtools")
install.packages("raster")
install.packages("sp")
install.packages("spdep")
install.packages("spatial")
install.packages("gtools")
install.packages("gtools")
install.packages("sandwich")
install.packages("multcomp")
```

Now install FIELDImageR using the install_github function from devtools package. If necessary, use the argument type="source"

```
devtools::install_github("OpenEcology/FIELDimageR")
```

If the method above doesn't work, use the zip file from GitHub by downloading the FIELDImageR-master.zip file

```
setwd "/Users/salvadorgezan/Desktop/FIELDimageR-master"
devtools::install("FIELDimageR-master", dependencies=TRUE)
library(FIELDimageR)
install.packages("/Users/salvadorgezan/Desktop/FIELDimageR-master.tar.gz", repos = NULL, type="source")
```

Step 4: Install the FIELDimageR "FIELDimageR" using the zip file
Step 4.1: Click on "Clone or download"
Step 4.2: Click on "Download ZIP"
Step 4.3: Open Finder and make sure to find the right package version
Step 4.4: Click on the "FIELDimageR-master.zip" in order to extract the package folder "FIELDimageR-master"
Step 4.5: Open R and change path to the right package version
Step 4.6: Install the package using the "devtools" library
Step 4.7: Load the package "FIELDimageR"
Step 4.8: Install the package using the "install.packages" function
Step 4.9: Load the package "FIELDimageR"
Step 4.10: Check your version of the package
Step 4.11: Update the package if needed
Step 4.12: Install the "EBImage" package
Step 4.13: Load the "EBImage" package
Step 4.14: Check the "EBImage" version
Step 4.15: Update the "EBImage" if needed
Step 4.16: Check the "EBImage" version
Step 4.17: Load the "FIELDimageR" and "EBImage" packages
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Kim Eddy and Julia Hill Bingham Hales MacPhail can each be thanked for pulling each Yellowbrick over to run from end-to-end and breaking pulls and pushes.

```
# Load Yellowbrick
!pip install -U yellowbrick[demo]
# Import the Image Classification Dataset
!yb.image.download_dataset -d fruits
# Import the Yellowbrick Image Utilities
import yellowbrick.image as yb.image
```

```
Collecting yellowbrick[demo]
  Downloading yellowbrick-1.4-py3-none-any.whl (1.3 MB)
     |____________________________________| 1.3 MB 5.1 MB/s
Requirement already satisfied: scikit-learn>=1.0,<1.2 in /usr/local/lib/python3.7/dist-packages (1.0.2)
Requirement already satisfied: numpy>=1.16.0,<1.22 in /usr/local/lib/python3.7/dist-packages (1.21.6)
Requirement already satisfied: cycler>=0.10.0,<0.11 in /usr/local/lib/python3.7/dist-packages (0.10.0)
Requirement already satisfied: matplotlib>=3.0.0,<3.5.0,!=3.3.0,!=3.3.1,!=3.3.2,!=3.3.3,!=3.3.4,!=3.3.5,!=3.3.6,!=3.3.7,!=3.3.8,!=3.3.9,!=3.4.0,!=3.4.1,!=3.4.2,!=3.4.3,!=3.4.4,!=3.4.5,!=3.4.6,!=3.4.7,!=3.4.8,!=3.4.9,!=3.4.10,!=3.4.11,!=3.4.12,!=3.4.13,!=3.4.14,!=3.4.15,!=3.4.16,!=3.4.17,!=3.4.18,!=3.4.19,!=3.4.20,!=3.4.21,!=3.4.22,!=3.4.23,!=3.4.24,!=3.5.0,!=3.5.1,!=3.5.2,!=3.5.3,!=3.5.4,!=3.5.5,!=3.5.6,!=3.5.7,!=3.5.8,!=3.5.9,!=3.5.10,!=3.5.11,!=3.5.12,!=3.5.13,!=3.5.14,!=3.5.15,!=3.5.16,!=3.5.17,!=3.5.18,!=3.5.19,!=3.5.20,!=3.5.21,!=3.5.22,!=3.5.23,!=3.5.24,!=3.6.0,!=3.6.1,!=3.6.2,!=3.6.3,!=3.6.4,!=3.6.5,!=3.6.6,!=3.6.7,!=3.6.8,!=3.6.9,!=3.6.10,!=3.6.11,!=3.6.12,!=3.6.13,!=3.6.14,!=3.6.15,!=3.6.16,!=3.6.17,!=3.6.18,!=3.6.19,!=3.6.20,!=3.6.21,!=3.6.22,!=3.6.23,!=3.6.24,!=3.7.0,!=3.7.1,!=3.7.2,!=3.7.3,!=3.7.4,!=3.7.5,!=3.7.6,!=3.7.7,!=3.7.8,!=3.7.9,!=3.7.10,!=3.7.11,!=3.7.12,!=3.7.13,!=3.7.14,!=3.7.15,!=3.7.16,!=3.7.17,!=3.7.18,!=3.7.19,!=3.7.20,!=3.7.21,!=3.7.22,!=3.7.23,!=3.7.24,!=3.8.0,!=3.8.1,!=3.8.2,!=3.8.3,!=3.8.4,!=3.8.5,!=3.8.6,!=3.8.7,!=3.8.8,!=3.8.9,!=3.8.10,!=3.8.11,!=3.8.12,!=3.8.13,!=3.8.14,!=3.8.15,!=3.8.16,!=3.8.17,!=3.8.18,!=3.8.19,!=3.8.20,!=3.8.21,!=3.8.22,!=3.8.23,!=3.8.24,!=3.9.0,!=3.9.1,!=3.9.2,!=3.9.3,!=3.9.4,!=3.9.5,!=3.9.6,!=3.9.7,!=3.9.8,!=3.9.9,!=3.9.10,!=3.9.11,!=3.9.12,!=3.9.13,!=3.9.14,!=3.9.15,!=3.9.16,!=3.9.17,!=3.9.18,!=3.9.19,!=3.9.20,!=3.9.21,!=3.9.22,!=3.9.23,!=3.9.24,!=3.10.0,!=3.10.1,!=3.10.2,!=3.10.3,!=3.10.4,!=3.10.5,!=3.10.6,!=3.10.7,!=3.10.8,!=3.10.9,!=3.10.10,!=3.10.11,!=3.10.12,!=3.10.13,!=3.10.14,!=3.10.15,!=3.10.16,!=3.10.17,!=3.10.18,!=3.10.19,!=3.10.20,!=3.10.21,!=3.10.22,!=3.10.23,!=3.10.24,!=3.11.0,!=3.11.1,!=3.11.2,!=3.11.3,!=3.11.4,!=3.11.5,!=3.11.6,!=3.11.7,!=3.11.8,!=3.11.9,!=3.11.10,!=3.11.11,!=3.11.12,!=3.11.13,!=3.11.14,!=3.11.15,!=3.11.16,!=3.11.17,!=3.11.18,!=3.11.19,!=3.11.20,!=3.11.21,!=3.11.22,!=3.11.23,!=3.11.24,!=3.12.0,!=3.12.1,!=3.12.2,!=3.12.3,!=3.12.4,!=3.12.5,!=3.12.6,!=3.12.7,!=3.12.8,!=3.12.9,!=3.12.10,!=3.12.11,!=3.12.12,!=3.12.13,!=3.12.14,!=3.12.15,!=3.12.16,!=3.12.17,!=3.12.18,!=3.12.19,!=3.12.20,!=3.12.21,!=3.12.22,!=3.12.23,!=3.12.24,!=3.13.0,!=3.13.1,!=3.13.2,!=3.13.3,!=3.13.4,!=3.13.5,!=3.13.6,!=3.13.7,!=3.13.8,!=3.13.9,!=3.13.10,!=3.13.11,!=3.13.12,!=3.13.13,!=3.13.14,!=3.13.15,!=3.13.16,!=3.13.17,!=3.13.18,!=3.13.19,!=3.13.20,!=3.13.21,!=3.13.22,!=3.13.23,!=3.13.24,!=3.14.0,!=3.14.1,!=3.14.2,!=3.14.3,!=3.14.4,!=3.14.5,!=3.14.6,!=3.14.7,!=3.14.8,!=3.14.9,!=3.14.10,!=3.14.11,!=3.14.12,!=3.14.13,!=3.14.14,!=3.14.15,!=3.14.16,!=3.14.17,!=3.14.18,!=3.14.19,!=3.14.20,!=3.14.21,!=3.14.22,!=3.14.23,!=3.14.24,!=3.15.0,!=3.15.1,!=3.15.2,!=3.15.3,!=3.15.4,!=3.15.5,!=3.15.6,!=3.15.7,!=3.15.8,!=3.15.9,!=3.15.10,!=3.15.11,!=3.15.12,!=3.15.13,!=3.15.14,!=3.15.15,!=3.15.16,!=3.15.17,!=3.15.18,!=3.15.19,!=3.15.20,!=3.15.21,!=3.15.22,!=3.15.23,!=3.15.24,!=3.16.0,!=3.16.1,!=3.16.2,!=3.16.3,!=3.16.4,!=3.16.5,!=3.16.6,!=3.16.7,!=3.16.8,!=3.16.9,!=3.16.10,!=3.16.11,!=3.16.12,!=3.16.13,!=3.16.14,!=3.16.15,!=3.16.16,!=3.16.17,!=3.16.18,!=3.16.19,!=3.16.20,!=3.16.21,!=3.16.22,!=3.16.23,!=3.16.24,!=3.17.0,!=3.17.1,!=3.17.2,!=3.17.3,!=3.17.4,!=3.17.5,!=3.17.6,!=3.17.7,!=3.17.8,!=3.17.9,!=3.17.10,!=3.17.11,!=3.17.12,!=3.17.13,!=3.17.14,!=3.17.15,!=3.17.16,!=3.17.17,!=3.17.18,!=3.17.19,!=3.17.20,!=3.17.21,!=3.17.22,!=3.17.23,!=3.17.24,!=3.18.0,!=3.18.1,!=3.18.2,!=3.18.3,!=3.18.4,!=3.18.5,!=3.18.6,!=3.18.7,!=3.18.8,!=3.18.9,!=3.18.10,!=3.18.11,!=3.18.12,!=3.18.13,!=3.18.14,!=3.18.15,!=3.18.16,!=3.18.17,!=3.18.18,!=3.18.19,!=3.18.20,!=3.18.21,!=3.18.22,!=3.18.23,!=3.18.24,!=3.19.0,!=3.19.1,!=3.19.2,!=3.19.3,!=3.19.4,!=3.19.5,!=3.19.6,!=3.19.7,!=3.19.8,!=3.19.9,!=3.19.10,!=3.19.11,!=3.19.12,!=3.19.13,!=3.19.14,!=3.19.15,!=3.19.16,!=3.19.17,!=3.19.18,!=3.19.19,!=3.19.20,!=3.19.21,!=3.19.22,!=3.19.23,!=3.19.24,!=3.20.0,!=3.20.1,!=3.20.2,!=3.20.3,!=3.20.4,!=3.20.5,!=3.20.6,!=3.20.7,!=3.20.8,!=3.20.9,!=3.20.10,!=3.20.11,!=3.20.12,!=3.20.13,!=3.20.14,!=3.20.15,!=3.20.16,!=3.20.17,!=3.20.18,!=3.20.19,!=3.20.20,!=3.20.21,!=3.20.22,!=3.20.23,!=3.20.24,!=3.21.0,!=3.21.1,!=3.21.2,!=3.21.3,!=3.21.4,!=3.21.5,!=3.21.6,!=3.21.7,!=3.21.8,!=3.21.9,!=3.21.10,!=3.21.11,!=3.21.12,!=3.21.13,!=3.21.14,!=3.21.15,!=3.21.16,!=3.21.17,!=3.21.18,!=3.21.19,!=3.21.20,!=3.21.21,!=3.21.22,!=3.21.23,!=3.21.24,!=3.22.0,!=3.22.1,!=3.22.2,!=3.22.3,!=3.22.4,!=3.22.5,!=3.22.6,!=3.22.7,!=3.22.8,!=3.22.9,!=3.22.10,!=3.22.11,!=3.22.12,!=3.22.13,!=3.22.14,!=3.22.15,!=3.22.16,!=3.22.17,!=3.22.18,!=3.22.19,!=3.22.20,!=3.22.21,!=3.22.22,!=3.22.23,!=3.22.24,!=3.23.0,!=3.23.1,!=3.23.2,!=3.23.3,!=3.23.4,!=3.23.5,!=3.23.6,!=3.23.7,!=3.23.8,!=3.23.9,!=3.23.10,!=3.23.11,!=3.23.12,!=3.23.13,!=3.23.14,!=3.23.15,!=3.23.16,!=3.23.17,!=3.23.18,!=3.23.19,!=3.23.20,!=3.23.21,!=3.23.22,!=3.23.23,!=3.23.24,!=3.24.0,!=3.24.1,!=3.24.2,!=3.24.3,!=3.24.4,!=3.24.5,!=3.24.6,!=3.24.7,!=3.24.8,!=3.24.9,!=3.24.10,!=3.24.11,!=3.24.12,!=3.24.13,!=3.24.14,!=3.24.15,!=3.24.16,!=3.24.17,!=3.24.18,!=3.24.19,!=3.24.20,!=3.24.21,!=3.24.22,!=3.24.23,!=3.24.24,!=3.2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```

Menu

17. Saving output files

```
### Images (single and multi layers)
writeRaster(EXI_Indices, filename="EXI_Indices.tif", options=("INTERLEAVE=BAND", overwrite=TRUE)
# EXI_Indices.2 <- stack("EXI_Indices.tif") # Reading the saved image.

### Shapefile file
library(rgdal)
writeOGR(EXI_FieldShape, ".", "EXI_FieldShape", driver="ESRI Shapefile")
# EXI_FieldShape.2 <- readOGR("EXI_FieldShape.shp") # Reading the saved shapefile.

### CSV file (table)
write.csv(EXI_InfoFieldSuperdata_File = "EXI_Info.csv", row.names = T,row.names = F)
# Data.EXI_Info=read.csv("EXI_Info.csv",header= T,check.names = F) # Reading the saved data table.
```

Menu

Orthomosaic using the open source software OpenDroneMap

Image stitching from remote sensing phenotyping platforms (sensors attached to aerial or ground vehicles) in one orthophoto.

1) Follow the OpenDroneMap's documentation according to your operating system (Windows, macOS or Linux) to install **WebODM**.

2) Start WebODM and **Add Project** to upload your pictures (.tif or .jpg). Attached is one example of RGB images from experimental trials of UW-Madison Potato Breeding and Genetics Laboratory during the flowering time at Hancock Agricultural Research Station. Flight altitude was 60 m above ground, flight speed was 24 km/h, and image overlap was 75%. Download pictures here.

3) After the running process 'completed', download the **odm_orthophoto.tif** and **dsm.tif** to upload in R. Then follow the pipeline of FIELDimageR. Download the final odm_orthophoto.tiff

```
# Uploading file (odm_orthophoto.tif)
EX.DSM=stack("odm_orthophoto.tif")
plotRGB(EX.DSM, r = 1, g = 2, b = 3)

# Cropping the image to select only one trial (Selecting the same trial as EX.2 from step.13)
EX.DSM.Crop <- drawCrop(mosaic = EX.DSM)

# Rotating the image using the same theta from step 3:
EX.DSM.Rotated=fieldRotate(EX.DSM,Crop,theta = 2.3)

# Removing soil
EX.DSM.NoSoil<- fieldMask(mosaic = EX.DSM.Rotated)

# Building indices
EX.DSM.Indices <- fieldIndex(EX.DSM.NoSoil)$mosaic[[c(Red=1,Green=2,Blue=3,
                             Index = c("NGRDI","BGI"), myIndex = c("Red+Blue/Green"))]
# Extracting data using the same FieldShape file from step 5
EX.DSM.Info<- fieldInfo(mosaic = EX.DSM.Indices[myIndex,Red=1,Green=2,Blue=3,
                        FieldShape = EX.ShapeFieldShape,n.core = 3)

EX.DSM.InfoplotVolumeByIndex
```

Menu

Parallel and loop to evaluate multiple images

The following code can be used to evaluate multiple images (e.g. root area, leave indices, damaged area, ears, seed, structures, etc.). The example below is evaluating disease damage in images of leaves (affected area and indices). Download the example here.

```
# Images names (Folder directory: "./images")
pics= list.files("./images")

# Vegetation indices
Index= c("NGRI","VARI","GLI")

##########
### Loop ###
##########

system.time( # system.time: used to compare the processing time using loop and parallel
EX.Table.Loop=NULL
for(i in 1:length(pics)){
  EX.L1= stack(paste("./images/",pics[i],sep ="/"))
  EX.L1=fieldMask(EX.L1)
  EX.L1.Shape= fieldPolygon(mosaic=EX.L1, extent=T, plot=F # extent=T:The whole image area will be the shapefile
  EX.L2= fieldMask(mosaic=EX.L1, Index="NGRI", crop=FalseC=0.6, cropBoxes= F, plot=F # Select one index to identify l
  EX.L3= fieldMask(mosaic=EX.L1[[cropBoxes=F]], Index="VARI", crop=FalseC=0.1, cropBoxes= F, plot=F # Select one index to
  EX.L4= fieldIndex(mosaic=EX.L1[[cropBoxes]], Index=Index, plot=F # Indices
  EX.L5= stack(EX.L1,mask, EX.L4[[Index]]) # Making a new stack raster with new layers (demage area and indices)
  EX.L.Info= fieldInfo(mosaic=EX.L5, FieldShape=EX.L.Shape[[FieldShape, projection=F]] # projection=F (Ignore proje
  EX.L.Info.plot= EX.L.Info[-c(1:3)]
  EX.Table.Loop= rbind(EX.Table.Loop, EX.L.InfoplotValue) # Combine information from all images in one table
}
rownames(EX.Table.Loop)= pics
EX.Table.Loop

##############
### Parallel ###
##############

# Required packages
library(parallel)
library(foreach)
library(doParallel)

# Number of cores
n.core=detectCores() -1

# Starting workers
c1 <- makeCluster(n.core, output = "")
registerDoParallel(c1)
system.time(
EX.Table.Parallel <- foreach(i = 1:length(pics), .packages = c("raster","FIELDimageR"),
                             .combine = rbind) %dopar%{
  EX.L1= stack(paste("./images/",pics[i],sep ="/"))
  EX.L1.Shape= fieldPolygon(mosaic=EX.L1, extent=T, plot=F # extent=T:The whole image area w
  EX.L2= fieldMask(mosaic=EX.L1, Index="NGRI", crop=FalseC=0.6, cropBoxes= F, plot=F # Select on
  EX.L3= fieldMask(mosaic=EX.L1[[cropBoxes=F]], Index="VARI", crop=FalseC=0.1, cropBoxes= F, plot=F
  EX.L4= fieldIndex(mosaic=EX.L1[[cropBoxes]], Index=Index, plot=F # Indices
  EX.L5= stack(EX.L1,mask, EX.L4[[Index]]) # Making a new stack raster with new layers (demag
  EX.L.Info= fieldInfo(mosaic=EX.L5, FieldShape=EX.L.Shape[[FieldShape, projection=F]] # proje
  EX.L.InfoplotValue # Combine information from all images in one table
}
rownames(EX.Table.Parallel)= pics
EX.Table.Parallel
```

Menu

Quick tips (image analyze in R)

1) Changing memory limits in R

```
# The rasterOptions() allows you to customize your R session (raster package):
rasterOptions()
rasterOptions(chunksize = 5e+00)
rasterOptions(maxmemory = 5e+00)
```

2) Reducing resolution for fast analysis

```
new_mosaic=aggregate(previous_mosaic, fact=4)
```

3) Removing pressus files after used (more space in R memory): If you do not need one mosaic you should remove it to save memory to the next steps (e.g. the first input mosaic).

```
rm(previous_mosaic)
```

4) Using ShapeFile from other software (e.g. QGIS)

```
library(rgdal)
ShapeFile <- readOGR("Other_Software_Shapefile.shp")
```

5) Combining ShapeFiles: sometimes it is better to split the mosaic into smaller areas to better draw the shapefile. For instance, the user can combine the split shapefiles to one for the next step as extractors.

```
ShapeFile <- rbind(ShapeFile1, ShapeFile2, ShapeFile3, ...)
```

6) External window to amplify the RStudio plotting area (it helps to visualize and click when using functions: **fieldCrop**, **fieldMaskPoly**, **fieldShape**, and **fieldPolygon**). The default graphics device is normally "RStudioGD". To change use "windows" on Windows, "quartz" on MacOS, and "X11" on Linux.

```
# Example in macOS (type the following code before running FIELDimageR functions):
options(device = "quartz")
```

Menu

YouTube Tutorial

FIELDimageR: A tool to analyze orthomosaic images from agricultural field trials in R (Basic Pipeline)

FIELDimageR: Counting the number of plants (fieldCount)

FIELDimageR: Calculating vegetation indices (NDVI and NDRE)

FIELDimageR: Estimate plant height using the canopy height model (CHM)

FIELDimageR courses

- **Embrapa Beef Cattle**: https://fieldimager.cnpgc.embrapa.br/cursos.html

- **Embrapa Maize & Sorghum**: https://fieldimager.cnpms.embrapa.br/cursos.html

- **Universidade Federal de Viçosa (UenoBerhan)**: https://geomatica-fieldimager.UenoBerhan.com/FIELDimageR_Course%20Q3.html

14 de Agosto
10 às 14hs
Aulas de mapas ao programa de informações de plantas
Post Doctoral Research Scientist at University of Wisconsin
Brazil
Madison
Viçosa
Prof. Dr. Lucas Berhan Ueno
Prof. Dr. Lucas Berhan Ueno
Prof. Dr. Lucas Berhan Ueno