UAV high-throughput phenotyping Summary

Amir Ibrahim, Mahendra Bhandari, Jinha Jung, Jose Landivar, Ismaila Abiola Olaniyi

List of spectral vegetation indices developed

Feature Name	Formula	Abbreviation
Canopy Cover	-	CC
95th percentile Canopy Height	$CHM = DSM - DTM$	CH
Canopy Volume	-	CV
Average Excess Green Index	$ExG = 2G - R - B$	ExG
Average Normalized Difference Vegetation Index (NDVI)	$\frac{NIR - R}{NIR + R}$	NDVI
Average Normalized Difference Red Edge Index (NDRE)	$\frac{NIR - RE}{NIR + RE}$	NDRE

NOTE: CHM: Canopy Height Model, DTM: Digital Terrain Model, DSM: Digital Surface Model. Reflectance obtained in the red band is denoted by R, green band by G, red edge by RE, and near infrared by NIR.

UAV Data Collection and Processing Update

Location	Flights	UAS-Hub Project created	Processing & Data Delivery	Notes
TX-College Station/McGregor	25	2022 College Station Winter Wheat/ 2022 McGregor Wheat	CC, CH, CV, ExG, NDVI, NDRE¶	McGregor NDVI and NDRE not processed yet
TX-Amarillo Irrigated	23	2022 Amarillo Irrigated	CC, CH, CV, ExG, NDVI, NDRE	-
Kansas-Colby	12	2022 Colby Wheat	CC, CH, CV, ExG, NDVI, NDRE	-
Kansas-Hays	7	2022 Hays Wheat	CC, CH, CV, ExG, NDVI, NDRE	Need to re-upload the 06/16 flight
UC Davis	9	2022 DA Wheat Irrigation	CC, CH, CV, ExG, NVDI, NDRE	-

UAV Data Collection and Processing Update

Location	Flights	UAS-Hub Project created	Processing & Data Delivery	Notes
Idaho	11	2022 Idaho Wheat	Waiting for boundary correction	-
Cornell	2	2022 Cornell Wheat	Expected Delivery: 10/31/2022	Needed Plot Layout (received 9/28/2022)
WSU (Washington)	4	2022 Washington Wheat	Expected Delivery: 10/31/2022	Need Plot Layout (contacted on 8/27/2022)
UIUC	8	2022 UIUC Wheat – St. Peter	Expected Delivery: 10/31/2022	Need Plot Layout (received 9/28/2022)
UNL Lincoln/Sidney	4/6	2022 UNL Wheat – Lincoln	Expected Delivery: 10/31/2022	Lincoln: Need GCPs & re-upload 0602_sfyld flight Sidney: Need GCPs & re-upload 0527_multi, 0616_multi, 0616_rgb, 0718_multi flights
USU (Utah)	6	2022 Utah Wheat	Expected Delivery 10/31/2022	Need to re-upload 06/21 and 07/05 flights

Programs that will process their own UAS data

- Example programs
  - Colorado State University
  - Oklahoma State University
  - Virginia Tech
- Tasks
  - Report the number of flights
  - Status of data analysis
  - Submit to T3

Bottlenecks: Efficient Data Processing & Delivery

- Programs use different sensors (from the proposed sensors and platforms - See User's Manual)
- Programs not following data collection and transferring protocol
  - Data upload protocol not followed: uploading photos individually, instead of uploading the whole flight as a single zip file.
  - Field layout not clearly documented
  - Incomplete submission (have to wait for GCP survey results to start processing)
  - Problems with GCPs
    - Some programs used white square plates as GCPs without a black & white cross pattern
    - GCPs were removed or covered by plants

Bottlenecks: Efficient Data Processing & Delivery

- Boundary creation and matching with field layout is very time-consuming (read the manual)
  - Takes 2-3 days to do boundary delineation for a single field
- If no dataset collected before plant emergence (read the manual)
  - Certain phenotypic features (canopy height and canopy volume) can't be reliably computed
  - Long process
    - interpolation procedure to create the Digital Terrain Model
      - Requires a significant manual process and takes a lot of time and effort

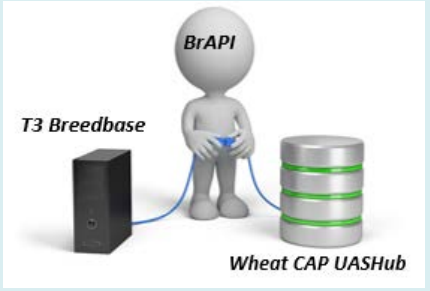
Bottlenecks: Efficient Data Processing & Delivery

- Please read and follow the User's Manual
- Each of the 19 programs is allowed 1 location, two acres, two sensors (RGB and Multi-spectral), 10 flights
- The location must be a spatially continuous field. When you have two fields that are smaller than 1 acre each and they are not spatially connected, it will be considered as two locations even though the total area is less than 2 acres.
- Fly only the WheatCAP germplasm
- Train students to do the plot boundaries (see Manual)
- Submit your data as soon as possible after each flight
- Please send your field layout and plot details in Excel templates ASAP (See Manual)
- Smooth transfer of field layout and plot detail from programs to T3 and UAS-Hub is of paramount importance and requires cooperation
- The UAS-Hub and A&M team is not a service component

PYTHON CODE DEVELOPMENT

```
#!/usr/bin/env python
# coding: utf-8

# ### Importing the libraries

# In[1]:


import requests
import pandas as pd
import numpy as np


# #### Input the Trial_ID

# In[2]:


#---Specifying the ID of the trial to collect from T3
trial_id = 9324


# In[3]:


#---Connecting to the T3 Breedbase using the endpoints
auth_key = "xqthjomydxyqmphonizvmsebiatyzvzhhcoaithzfingdzsbmzrqvufjowdmblvqqymrlmb" #---not really in u

api_base_url = "https://wheatcap.triticeaetoolbox.org"

endpoint_path = f"/brapi/v2/observationunits?studyDbId={trial_id}&pageSize=1000" #--Page size was kept a

endpoint = f"{api_base_url}{endpoint_path}"

head = {'Authorization': 'token {}'.format(auth_key)}

#----The request
r = requests.get(endpoint, headers=head)
```

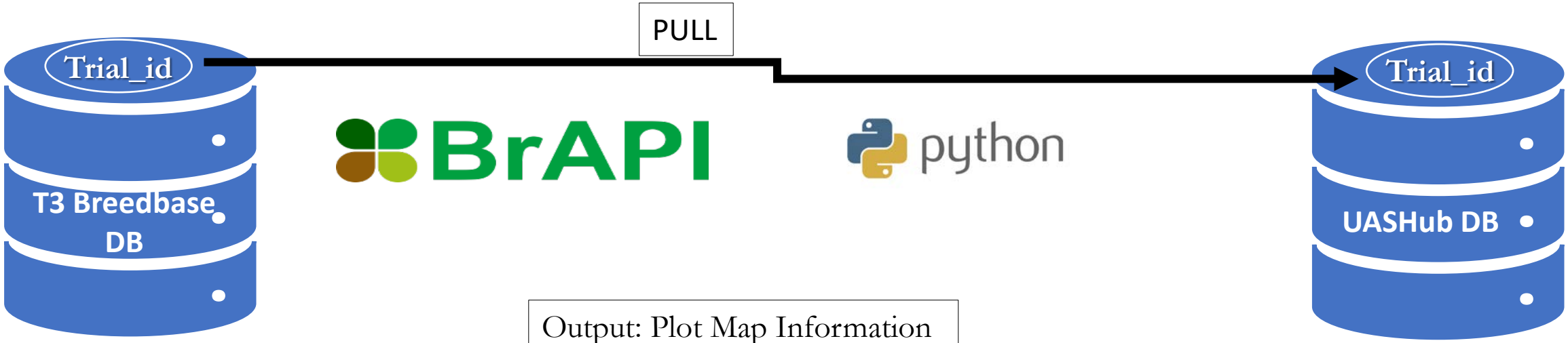
```
olani@ISMAIL MINGW64 ~/OneDrive/Desktop/GDSL/BrAPI
$ python BrAPI_Plots_08-02-22.py
```



BrAPI

- BrAPI – Breeding Application Programming Interface
  - Interchanging plant phenotypic and genotypic information between crop breeding applications
  - The Python code gets input as the Trial_id and gives a response in the form of plot map information in csv format.

WORKFLOW

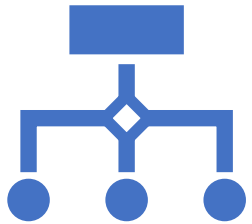


Output: Plot Map Information

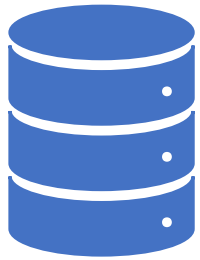
Name	PLOT_ID	studyDbId	studyName	Column	Row	PLOT_NO
TAM W-101	1371009	9324	TXE_2022_Bushland-Irrigated	1	1	1
TAM 114	1370962	9324	TXE_2022_Bushland-Irrigated	2	1	2
TAM 115	1370965	9324	TXE_2022_Bushland-Irrigated	3	1	3
TAM 204	1370951	9324	TXE_2022_Bushland-Irrigated	4	1	4
TAM 205	1371011	9324	TXE_2022_Bushland-Irrigated	5	1	5
TAM 304	1370997	9324	TXE_2022_Bushland-Irrigated	6	1	6
AMPSY 473-18AZ816	1370959	9324	TXE_2022_Bushland-Irrigated	7	1	7
TX17M1572	1370992	9324	TXE_2022_Bushland-Irrigated	8	1	8
TX18A001119	1370977	9324	TXE_2022_Bushland-Irrigated	9	1	9
TX18A001129	1370994	9324	TXE_2022_Bushland-Irrigated	10	1	10
TX18A001132	1371015	9324	TXE_2022_Bushland-Irrigated	10	2	11
TX18A001399	1370957	9324	TXE_2022_Bushland-Irrigated	9	2	12
TX18M2602	1370956	9324	TXE_2022_Bushland-Irrigated	8	2	13
TX14M7088-18AZ530	1370938	9324	TXE_2022_Bushland-Irrigated	7	2	14
TX19A001030	1371020	9324	TXE_2022_Bushland-Irrigated	6	2	15
TX19A001150	1371001	9324	TXE_2022_Bushland-Irrigated	5	2	16

	1	2	3	4	5	6	7	8	9	10
12	120	119	118	117	116	115	114	113	112	111
11	101	102	103	104	105	106	107	108	109	110
10	100	99	98	97	96	95	94	93	92	91
9	81	82	83	84	85	86	87	88	89	90
8	80	79	78	77	76	75	74	73	72	71
7	61	62	63	64	65	66	67	68	69	70
6	60	59	58	57	56	55	54	53	52	51
5	41	42	43	44	45	46	47	48	49	50
4	40	39	38	37	36	35	34	33	32	31
3	21	22	23	24	25	26	27	28	29	30
2	20	19	18	17	16	15	14	13	12	11
1	1	2	3	4	5	6	7	8	9	10

WORK IN PROGRESS



PULL – done (Plot Map Information)



PUSH from UAShub DB to T3 Breedbase DB

Pushing phenotypic information.

Studying the data structure of T3 DB.

Linking the data from T3 with a unique identifier

Acknowledgments

- Texas A&M Team
  - Juan Landivar
  - Jackie Rudd
  - Shannon Baker
  - Russ Garretson
  - Shuyu Liu

UAS Hub Technical Support

- For technical support with the Wheat CAP UAS Hub, contact Jose L. Scott at: jose.landivarscott@ag.tamu.edu
- Office: (361) 265-9201
  - Access
  - Project creation
  - Data submission
  - Data download
  - Etc.