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ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features

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***ARIN® procedure for the normalization of multitemporal remote images
through vegetative pseudo-invariant features***

Content

- 1) Multitemporal images need calibration/ normalization
- 2) Absolute radiometric corrections (ARC) vs.
Relative radiometric normalization (RRN)
- 3) ARIN® procedure & software
- 4) ARIN contribute to normalize remote images of agricultural scenes
- 5) Projects, publications, registration and patent

A) Primary Process of Multi-temporal images

Calibration/ normalization

(If land uses are invariant features multitemporal images should be quasi-identical)

ARIN® procedure for the normalization of multitemporal remote images through vegetative pseudo-invariant features

1) Multitemporal images need calibration/ normalization

Remote images are usually instantaneous, affected by atmospheric conditions, sun angle, viewing angle, changes in soil & plant–atmosphere system, & in the sensor calibration over time

Absolute radiometric corrections (ARC)

Relate digital counts of image data to radiance at the surface of the Earth.
Requires sensor calibration coefficients + Atmospheric correction algorithm + Related input data, among other corrections.

For most historically remote scenes, these data are not available, and for planned acquisitions, the data may be difficult to obtain

Consequently, may not always be a practical method

Relative radiometric normalization (RRN)

based on the radiometric information intrinsic to the images themselves
(alternative when absolute surface radiances are not required).

RRN of imagery is important for many applications,
land cover change detection,
mosaicking and tracking
vegetation indices over time,
supervised and unsupervised land cover classification

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A PRACTICAL METHOD**

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RRN of imagery is VERY IMPORTANT For many applications,
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Many RRN methods:

Pseudo-invariant features (PIF)
Radiometric control set (RCS),
Image regression (IR)
No change (scatter-grams) (NC),
Histogram matching (HM),
Artificial neural net-work, etc. etc.

ALL THESE METHODS ARE BASED IN NON-VEGETATIVE FEATURES

ARIN is based in VEGETATIVE PSEUDO-INVARIANT FEATURES

ENVI 5.0

GeoEyes-1 satellite images, V1/April, V2..... V6....V7/October, 100 km2 scene, Southern Spain

Partial view of the vegetative pseudo-invariant features (VPIFs) used in this study:
a) CIT-citrus; b) OLI-olive; and c) POP-poplars. The VPIF SHP files are transposed automatically to other multi-temporal images during the ARIN process.

ARIN® procedure

- 1) selecting one or several *vegetative pseudo-invariant features* (VPIFs);
- 2) *defining the same parcel or parcels* for each selected VPIF in each multitemporal image;
- 3) *extracting the VPIF spectral bands data for each image*;
- 4) calculating the *correction factors* (CFs) for each image band to fit each band value to the average value of the image series; and
- 5) obtaining the normalized images by transforming EACH BAND OF EACH IMAGE through *CF linear functions*.

ARIN® software (to automate the ARIN procedure)

- Reduce drastically the required time of image processing, from hours to a few minutes,
- So, makes all the process economically feasible

Figure 3. NDVI evolution **variant features**: corn and wheat /image timing (V1- early April to V7-early October,

Figure 3. NDVI evolution in pseudo-invariant (a: CIT, citrus; and POP, poplar grove features. (V1- early April to V7-early October)

Figure 1. ARIN flowchart

ARIN software outcome for the CIT VPIF spectral bands of original GeoEye-1 images and the corresponding band correction factors are shown

Automatic Relative Images Normalization (ARIN)								
PIF-1	Original Image	Image	Blue	Green	Red	NIR	NDVI	B/G
		GeoEye Ventilla1 09April2010	420	333	188	1180	0,725	1,261
		GeoEye Ventilla2 01May2010	241	347	107	1248	0,842	0,695
		GeoEye Ventilla3 23May2010	513	443	300	1361	0,639	1,158
		GeoEye Ventilla4 20June2010	363	264	155	852	0,692	1,375
		GeoEye Ventilla5 09July2010	237	319	120	1048	0,795	0,743
		GeoEye Ventilla6 22August2010	322	247	149	815	0,691	1,304
		GeoEye Ventilla7 02October2010	209	262	92	853	0,805	0,798
		Mean	329	316	159	1051	0,737	1,041
		SD	110,943	68,195	70,206	218,32	0,513	1,627
	Correction Factor	CF1						
			0,785	0,949	0,844	0,89		
			1,364	0,912	1,475	0,842		
			0,642	0,714	0,529	0,772		
			0,908	1,198	1,025	1,233		
			1,386	0,993	1,322	1,003		
			1,023	1,283	1,067	1,289		
			1,577	1,206	1,724	1,232		

Table 1. Vegetative pseudo-invariant feature (VPIF) spectral band values of the original (ORIG) and VPIF ARIN-transformed (-transf.) images.

VPIF Images		Band	Series of images							Statistical		
			V1	V2	V3	V4	V5	V6	V7	Mean	Range	S. d.
CIT ¹	ORIG	B	420	241	513	363	237	322	209	329	304	111
		G	333	347	443	264	319	247	262	316	196	68
		R	188	107	300	155	120	149	92	159	208	70
		NIR	1180	1248	1361	852	1048	815	853	1051	546	218
	POP-transf.	B	334	335	347	310	341	324	307	328	40	15
		G	322	346	350	274	324	302	281	314	76	30
		R	158	158	197	133	175	142	129	156	68	24
		NIR	1173	1095	1192	904	1005	906	1031	1044	288	117
	OLI-transf	B	343	322	346	320	330	338	283	326	63	21
		G	342	323	352	289	309	323	266	315	86	30
		R	163	136	190	140	153	163	135	154	55	20
		NIR	1247	1120	1088	951	1000	1029	895	1047	352	117

Table 2. Selected vegetative pseudo-invariant feature (VPIF) vegetation indices of the original (ORIG) and VPIF ARIN-, QUAC- and FLAASH-transformed (-transf.) images.

VPIF	Images	VegIndex	Series of images							Statistical		
			V1	V2	V3	V4	V5	V6	V7	Mean	Range	S. d.
CIT	ORIG	NDVI	0,73	0,84	0,64	0,69	0,79	0,69	0,81	0,74	0,20	0,07
		B/G	1,26	0,69	1,16	1,38	0,74	1,30	0,80	1,05	0,68	0,29
	OLI+POP-transf.	NDVI	0,77	0,75	0,72	0,75	0,71	0,73	0,78	0,74	0,08	0,03
		B/G	1,02	0,96	0,98	1,12	1,04	1,06	1,08	1,04	0,16	0,06
	QUAC-transf.	NDVI	0,79	0,85	0,79	0,90	0,79	0,90	0,89	0,84	0,12	0,05
		B/G	0,44	0,57	0,24	0,43	0,54	0,43	0,47	0,45	0,33	0,11
	FLAASH-transf.	NDVI	0,76	0,69	0,80	0,74	0,78	0,78	0,79	0,76	0,11	0,04
		B/G	0,59	0,64	0,55	0,59	0,47	0,64	0,66	0,59	0,19	0,07

Table 3. Correlation coefficients between the spectral band CFs of VPIF CIT, OLI and POP

VPIF ¹	Spectral band				Overall
	B	G	R	NIR	
CIT vs OLI	0.97**	1.0**	0.97**	0.85*	0.96**
CIT vs POP	0.98**	0.91*	0.92*	0.89*	0.93**
OLI vs POP	0.99**	0.92*	0.93**	0.85*	0.92**
Overall	0.97**	0.93**	0.92**	0.87**	0.93**

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1Abbreviations: VPIF; vegetative pseudo-invariant features; CIT, citrus orchards; OLI, olive orchards; POP, riparian trees; B, blue; G, green, R, red, NIR, near-infrared; *Significant at P=0.05; **Significant at P=0.01

AUTOMATIC REMOTE IMAGE PROCESSING FOR AGRICULTURE

1) PREPROCESSING

1a) Geo-referencing / Co-registration

1b) Calibration

2) CROPPING SYSTEM CLASSIFICATION AND ISOLATION (CROPCLASS)

Parcel Definition

Isolated Parcels

3) IMPLEMENTATION OF PRECISION AGRICULTURE

CLUAS (Orchard Trees Assessment)

SARI (Herbaceous Input Prescription map)

4) SITE-SPECIFIC CROP INDEXES AT MICROPLOT LEVEL

- Biomass
- Leaf Area
- Stress Zones
- Chlorophyll
- Diseases Patches
- Nitrogen Content
- Weed Patches
- Others

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FINAL COMMENTS

- It is needed to incorporate specific modules for agriculture/ agri-environment studies
- Otherwise remote sensing will not be economically feasible for many agriculture applications/ uses
- **ARIN module will make very easy the normalization of agricultural scenes where pseudo-invariant features are identifiable**
- ARIN can not be used in desert and frozen areas (absence of vegetation)

Our ARIN add-on IS FREE for research groups upon request

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5) Projects, publications, registrations & patents (IAS-CSIC)

Projects (*Spanish Ministry of Science & Innovation*)

AGL2007- 60926 (2008-2010)

AGL2010- 15506 (2011-2014)

Paper: PLOS ONE (in progress)

Registration: ARIN® software (1391/2012, 16 November)

Patent: ARIN® procedure (28 Dec.2012, Priority number 320542012)

THANK YOU FOR YOUR ATTENTION