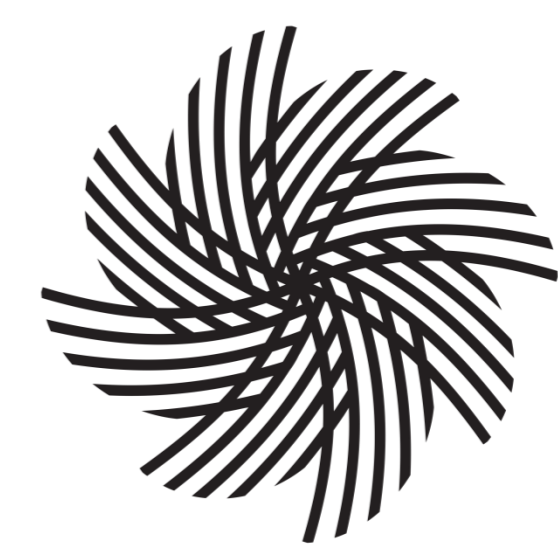# ARCA (Automatic Recognition of Color for Archaeology): a Desktop Application for Munsell Estimation

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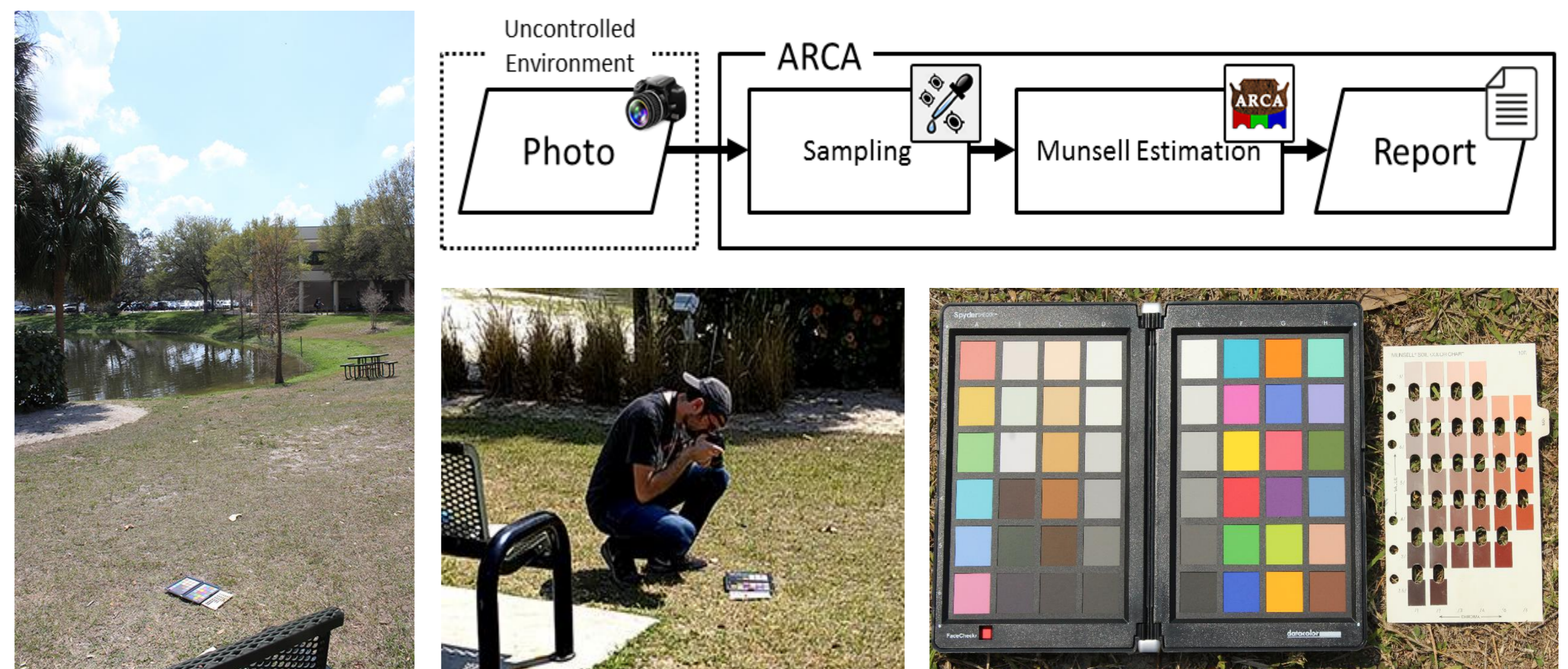11—15 September 2017
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Abstract

Archaeologists are used to employ the **Munsell Soil Charts** on cultural heritage sites to identify colors of soils and retrieved artifacts. The standard practice of Munsell estimation exploits the Soil Charts by *visual means*. This procedure is error prone, time consuming and very subjective. To obtain an accurate estimation the process should be repeated multiple times and possibly by other users, since colors might not be perceived uniformly by different people. Hence, a method for **objective and automatic Munsell estimation** would be a valuable asset to the field of archaeology. In this work we present **ARCA: Automatic Recognition of Color for Archaeology**, a desktop application for Munsell estimation. The following pipeline for Munsell estimation aimed towards archaeologists has been proposed: image acquisition of specimens, manual sampling of the image in the ARCA desktop application, automatic Munsell estimation of the sampled points and creation of a sampling report. A dataset, called **ARCA108**, consisting of **22,848 samples** has been gathered, in an *unconstrained environment*, and evaluated with respect to the Munsell Soil Charts. Experimental results are reported to define the best configuration that should be used in the acquisition phase. Color tolerance values of the proposed framework are also reported.

The dataset ARCA108 is publicly available online: http://iplab.dmi.unict.it/ARCA108

Pipeline

1. Acquisition phase (unconstrained environment)
2. Import data in ARCA Desktop Application
   - Manual Sampling:
     - pick-point(s) or draw-region(s)
   - Automatic Estimation
   - Report Creation


```
report.txt - Blocco note
File  Modifica  Formato  Visualizza  ?

Report of Munsell Estimation on image "3_10R_R_WBA_C.jpg" (Date: 06-Apr-2017)
S: single point, R: region

[1|S]: 2.5YR 6.0/6 (Quantizied from: 2.57YR 6.32/5.72), RGB=[208, 143, 121], position [2258, 3158]
[2|S]: 10.0R 5.0/6 (Quantizied from: 0.67YR 5.32/6.99), RGB=[187, 106, 89], position [2267, 2697]
[3|S]: 10.0R 4.0/8 (Quantizied from: 10.00R 4.17/7.68), RGB=[159, 76, 58], position [2263, 2220]

Generated by ARCA Desktop Application
```

Experimental Setting

- **8 order statistics:**
  - (Mean, Median, Mode, and Centroid) w/ and w/o Discretization
- **12 configurations:**
  - 2 devices: reflex camera and smartphone
  - 3 white balancing: auto, sunny, and cloudy
  - 1 fluorescence presetting: direct sunlight
  - 1 ISO setting: 400 ISO
  - 1 focus setting: autofocus
  - 2 kind of subject: w/ and w/o Macbeth Chart
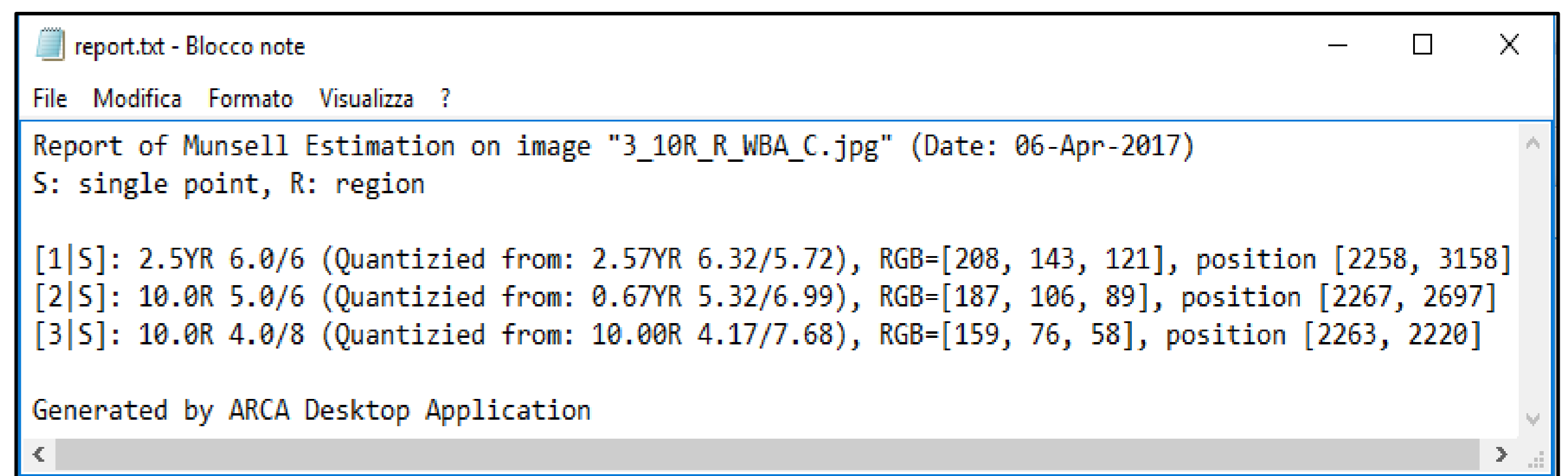
ARCA GUI

Already sampled points · Workspace (current image) · Open New Image · Pick-a-point · Draw-a-region · Zoom In/Out · Delete last picked point/region · Compute Munsell Notation of sampled point(s)/region(s) · Estimated Munsell Values · Save Report · Info panel about current operation
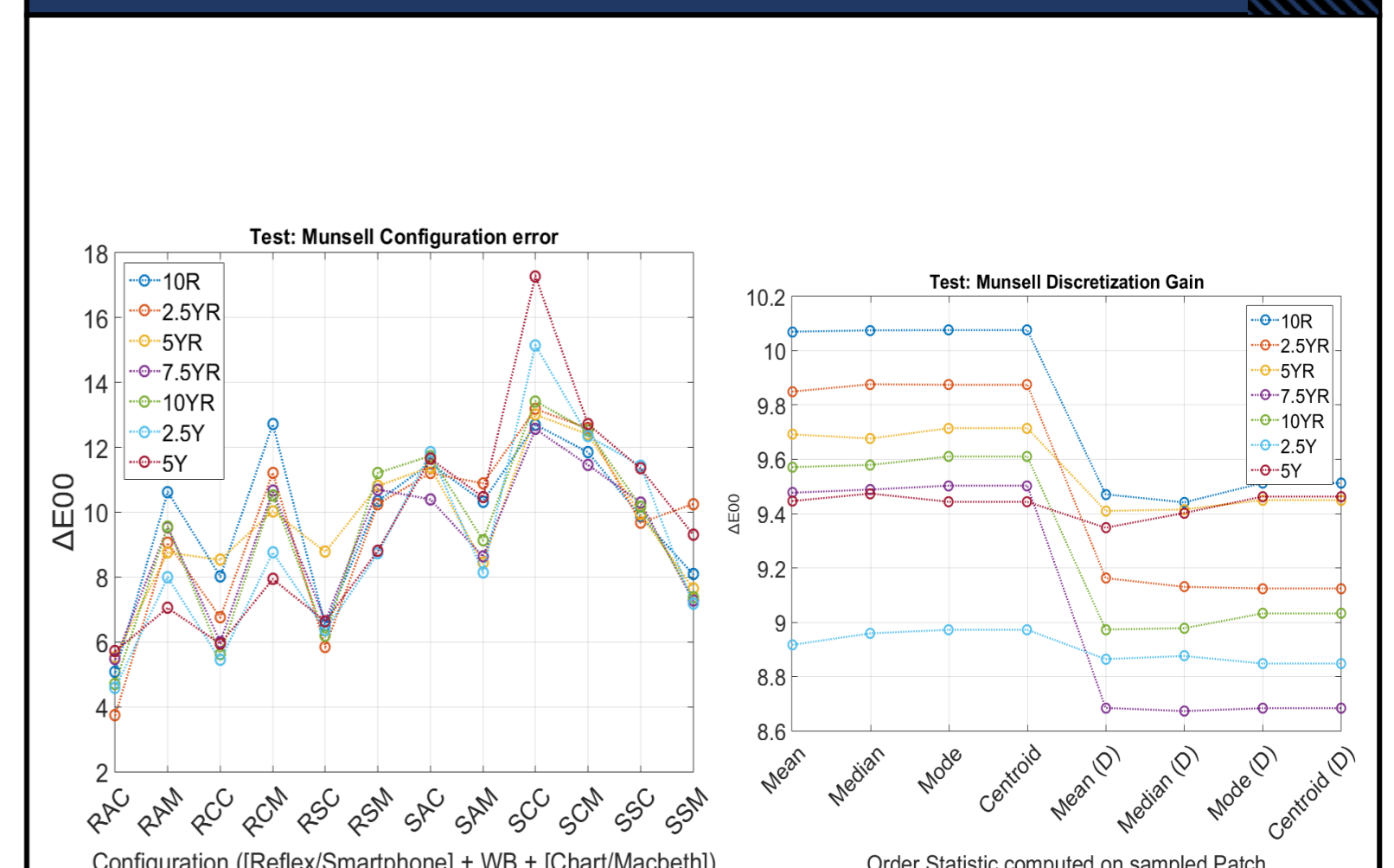
Experimental Results

Table 1. Mean and Standard Deviation of Munsell estimation for each one of the 12 defined configurations.

| | Configurations ([Reflex/Smartphone] + WB + [Chart/Macbeth]) | | | | | | | | | | | |
	RAC	RAM	RCC	RCM	RSC	RSM	SAC	SAM	SCC	SCM	SSC	SSM
Mean	*4.950*	8.992	6.626	10.338	6.691	10.169	11.381	9.436	13.786	12.264	10.352	8.198
St. D.	2.887	2.667	2.807	3.191	*2.562*	2.914	2.888	3.266	3.220	2.756	2.998	2.719

Conclusion

We performed the whole experiments in an uncontrolled environment. A dataset of **22,848 samples** has been gathered under the *uncontrolled environment assumption* and evaluated with respect to the Munsell reference Soil Charts. This dataset has been called **ARCA108** and it represents a new valuable asset for color specification research purposes. We defined **8 possible order statics** for characterize the samples and **12 possible configurations** during the acquisition phase. Experimental results shown that the defined order statistics reach very similar results, and that discretization of the converted Munsell notation decreases the error of ~1 CIELAB unit. The best configuration among the tested ones is **[Reflex, Auto White Balancing, Solo Chart]**, with **4.95±2.89 CIELAB units of error**. Compared to other related works, taking into account intrinsic error of Munsell reference Soil Charts and the uncontrolled experimental setting, this result is encouraging and reasonable. We proved that ARCA can represent for archaeologists a valid tool for color specification. ARCA allows archaeologists to select multiple samples and estimate the corresponding Munsell notation at once, in a fast, objective and deterministic way, avoiding the error-prone and time-consuming procedure of Munsell Estimation by visual means and without any expensive tool like spectophotometer, Munsell Soil Charts or Gretag-Macbeth color checker. For future works, we are planning to improve the ARCA application (i.e., image processing algorithms for noise reduction, deployment of a mobile version), to expand the validation phase acquiring other Munsell Soil Charts from Tropical Soils edition and, most of all, to conduct a color specification test-case on archaeological soils and pottery.

The method described in this work is part of the patent USF Ref. No.: 17A055 – "Automatic digital method for classification of colors in Munsell Color System".