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IMAGE AND IMAGE ANALYSIS

Document prepared by experts from France

IMAGE AND IMAGE ANALYSIS

UPOV has asked member States about their use of image and image analysis. Enquiries on this subject are available from the Office of UPOV.

Definitions:

- An image is a representation of reality, from a quick drawing summarizing the main aspects of an object, to a photograph, or a numerical capture for instance.

- A digital image is a spatial representation in a digital format of an object or of a two- or three-dimensional scene or of another image.

- Image analysis is a set of operations on an image in order to obtain parameters. The parameters can describe the shape of an object, the length or width of an organ, quantify color variegations of petals or leaves, etc. These operations can be performed by man on a regular photograph, or by computer software on digital image. Generally the term "image analysis" is used when digital images are analyzed by computer.

Use of Image and Image Analysis:

- Image and digital images can be used in order to keep memory of the objects studied.
- Image analysis provide tools to derive information from digital images. The principle is "image in" -> processing -> "data out"
- This information can then be used by the expert to describe the material and/or for decision making.

In this respect image analysis is not fundamentally different from visual assessment or other measurements obtained in the field or in the laboratory.

In the first part of this document, we give examples in which images, or image analysis, can be useful; in the second part we briefly describe image analysis; in a third part we summarize things to be aware of.

1 EXAMPLES

Photographs:

Photographs are used at different steps in variety testing, for instance:

- given by the breeder at the time of application. This gives the expert an idea of the type of material submitted. It can be kept as an element of description provided by the applicant, or can be used to prepare the studies by the examiner,
- Photographs (classical or digital) can be used to keep a record on the objects measured (field plots, plants, organs),
- Photographs have also been used in some gazettes or in other publications as information on protected varieties.

Digital Images :

Digital images can be used in a similar way to normal photographs. However, one should be aware of the resolution used. Typically the resolution of a 35 mm film is about 4000 lines, which is more than twice the resolution of high resolution digital cameras in year 2000.

Digital images offer however some clear advantages over normal photographs:

1. easy to copy and exchange
2. easy to enhance and manipulate
3. easy to store in databases
4. allow automatic measurements
5. allow automatic comparison and image retrieval

In order to use digital images for measurement or comparison (image matching), it is necessary to record the images under standardized conditions. Different apparatus can be used to capture images: scanner, classical or digital cameras for instance.

Improving Efficiency:

In combination with good logistic handling, image analysis can save a lot of time for measurements. It can also increase the precision of the measurement, especially compared with visual observations. Furthermore, it is possible to extract more information which could otherwise not be obtained, e.g. total shape analysis and shape similarity, quantification of variegation patterns, etc.

Images can be kept for long-term storage and further analysis, or only used for feature extraction. If the feature extraction is done “real time”, images might not be kept at all. It is also possible to do the analysis shortly after the image recording in batch or with interactive tools. The image capture can also be done quickly when the plants are at the right stage, and analysis performed later on, when the critical biological stage do not lock human resources.

Classical Measures with the Help of Images:

Simple classical measures, such as length, width, etc., can be obtained manually on photographs or automatically on digital images; instead of direct measure or visual assessment in the field or laboratory. Image analysis is used in this way for measuring size and shape of e.g. beans, carrots, onions, seeds, etc. Image analysis can help to perform classical examination, it is not reserved to “new” or “sophisticated” characteristics.

Analysis for Color Characterization:

By image analysis it is possible to compute respective area of several color zones in case of bicolor or variegated objects (leaves, petals). It is used to analyze color in Rose, to analyze color variegation patterns on Ficus benjamina, Dianthus, etc.

Electrophoretic Gels:

Electrophoresis is sometimes used in relation with studies on varieties. In some cases the gels are digitized, and specific software is used to identify and register the spots to be used in order to describe the variety.

Comparing Varieties with the Help of Images:

When images of different varieties have been collected in comparable conditions it is possible to compare them. Specific software can be used to retrieve the "similar varieties" from the database either from the content of one or more images, from the variety description, from molecular data or from any characteristic available. The database can be used to select the varieties with which the candidate should be cautiously compared. This is done either by a routine program, or by the expert who interactively manages the comparisons to be done according to the material or the objective of the study.

Identification, Post Control, etc:

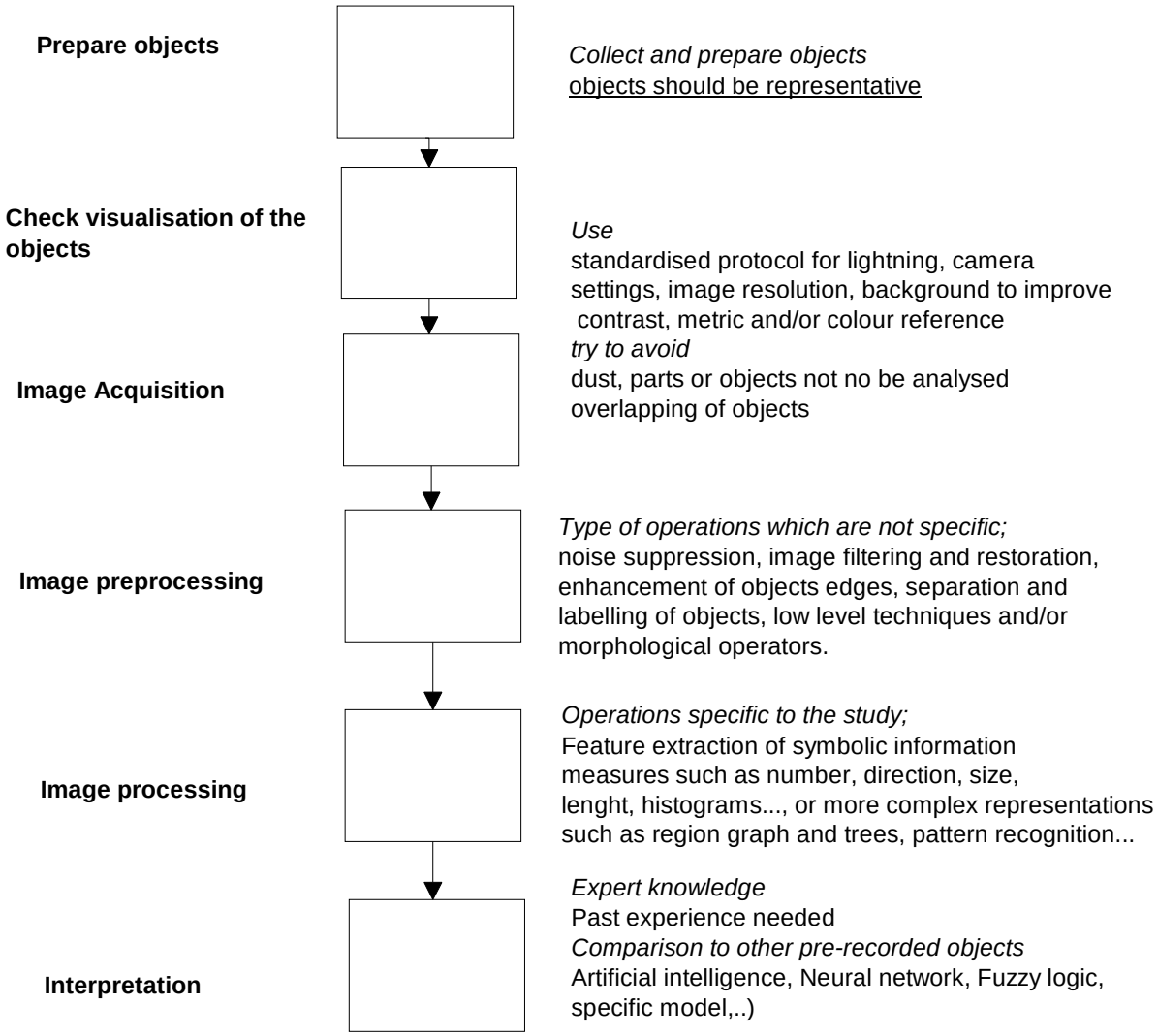
Various publications have shown that image analysis can be used with success to recognize species in mixtures, or a variety among others when compared to known references.

2 IMAGE PROCESSING, MAIN STEPS:

Beforehand:

Experiment machine and software, train people, check reliability and reproducibility
Look at existing protocols and define protocols to use
Define type of material, time of examination,...
Check variability within and intra-varietal variability
Check effect of environment

Image analysis



Describe material and/or use in a decision process

Keep memory of results and on how the results were obtained

3 THINGS TO BE AWARE OF:

Images offer only an instantaneous representation of reality. Experience and practice show that variability can occur according to growing conditions. This is also true for classical measurements made by visual assessment or direct measure, but should not be forgotten when images are used.

Sample Preparation:

Like in DUS testing the samples to be used must be representative of the variety. Image analysis can be used in order to study the variability (on a plant, on different plants from the same variety at a given time, on date or state of development to use, …). Which parts to take and how many should be described and known by the users (persons who prepare plants, process images, experts using the results).

Image Acquisition:

As far as possible the conditions of capture must be known and standardized. For cameras the light conditions, the distance to the object, the size should be controlled (integration of a scale on the image itself). For photographs, the film used has a great influence on the color but it is impossible to ask to the breeders to use the same kind of film. So, this problem must be taken into account at the interpretation stage. Whenever possible, a calibration procedure should be established and used.

Measure Itself:

Sometimes the software is a black box, and the user can only choose the determination of the parameter without any possibility to change the way it is obtained. In other cases, a specific software computation has been developed in order to obtain reliable and comparable values.

Processing Images:

Usually different treatments are applied to the raw image, (filters, opening, closing, edge detection, etc.) in order to improve the determination of the expected parameters. Whenever possible this processing should be documented and kept along with the data and the parameters.

Image Storage:

An initial reference image should be stored if it is possible. Then the choice of what to store (which steps of the process, in which format, how many by variety,…) is usually a compromise between many factors such as the capacity of storage, the technical needs to proceed to all treatments of the image, the further uses, etc. With a conveyor belt system, usually the data are extracted on the flight and no images are stored. For image databases, of course all images need to be stored. In that case, be cautious if you want to sacrifice image quality (JPEG compression) to save disk space. It is usually more expensive to have to record an image of insufficient quality twice, than it is to buy an extra disk.

Storage of Parameters:

The features obtained should be stored in files or databases. These data can be handled in a similar way as all other measured data in the field or the laboratory.

Color Reproduction :

Until now, the computer screens used to display the images are not able to give true colors: different screens will give visually different results for the same image. Also the cameras do not record color in the same way. Therefore, do not rely on the color seen on screen or print-out. Try to obtain the RGB-values as good as possible. Compare the RGB values, not the visual representation on the screen. Color reference patterns (like colorchecker for instance) might be helpful here. Good color reproduction is still very difficult and there is not yet a standard procedure within UPOV. Also we should keep in mind that the color of plants is highly influenced by the environment and we have to assess the color precision that can be used in comparisons between pictures, not recorded with the same environmental conditions.

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