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GENEVA

TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS

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TGP/12 SECTION 3: EXAMINATION OF COMBINED CHARACTERISTICS USING IMAGE ANALYSIS

Document prepared by experts from the United Kingdom

1. A number of papers on the topic of Image Analysis (IA) in DUS testing have been presented to the TWC since the late 1980s. These papers can be grouped into several classes:

(a) image systems in terms of hardware and software requirements.
(b) IA applications in terms of the management of reference collections (eg VISOR).
(c) IA used in a research environment and comparisons with manual methods of assessment.
(d) the application of IA in routine DUS testing situations.

This document focuses on (d).

2. Some recent TWC documents on this subject and examples of the application of image analysis for DUS testing in specific crops are provided in the Annex to this document.

3. Details of the required hardware and software are outside the scope of this document. A list of names and addresses of technical experts involved with image analysis can be found on the UPOV website.

4. This document seeks to outline the potential benefits from the routine application of IA methods in DUS testing, and issues that need to be considered in investigating and implementing such an approach. It is seen at this stage as a framework document to generate discussion and debate on this subject.

5. Much DUS testing involves the observation and recording of morphological characteristics of plants. These observations may be in the form of visual "scores", or may require measurements of some kind. There are various measurements that can be made, and in many species these are specified in UPOV Test Guidelines. Such characteristics could quantify aspects such as size, shape and color of organs such as seeds, cotyledons, leaflets, leaves, and pods. UPOV Test Guidelines do not generally prescribe how these measurements are to be made.

6. IA (also known as machine vision or automatic measurement) has been in use in some UPOV member States for many years. There are several potential advantages to the use of IA in DUS measurements:

(i) measurements can be treated in the same ways as measurements made by more traditional means. For example, COYD and COYU can be used for suitable characteristics.
(ii) IA measurements are more objective, accurate and reproducible. Automation reduces the scope for within-expert and expert-to-expert variability. Note it is sensible to verify this.
(iii) the IA process is usually non-destructive – so the measurement can be repeated if necessary.
(iv) images can be kept. These can be used to check measurements and as evidence in the event of a dispute. They can also be used to develop new IA measurements and for reference collection management.
(v) costs can be reduced by simultaneous measurement of several characteristics and by rapid measurement of characteristics that are time-consuming to measure by other means
(vi) new characteristics can be developed that could not (sensibly) be measured by other means. This is particularly advantageous in crops for which discrimination in difficult.

7. Experience has demonstrated that many of the benefits above can be realized. In cases where IA has been implemented, previously lengthy and tedious manual processes have been automated, enabling increased numbers of varieties to be analyzed with no increase in resources and producing additional benefits in improving the discrimination between varieties.

8. Digitized or digital images are already being used for automatic measurements in some species.

9. Digitized images can also be produced by scanning photographs for storage and retrieval in "image libraries" for use in the selection of close controls from large reference collections. Various apparatus can be used to produce digital images, including digital cameras, still video cameras and scanners.

10. Digital images usually consist of a rectangular array of pixels. More pixels means greater resolution – this can affect the accuracy of measurements. Gray-scale images have a

single number associated with each pixel representing the lightness/darkness at that point in the image. Color images often have three numbers associated with each pixel, representing the intensity of red, green and blue components.

11. The sequence of numbers describing an image is called a bitmap. Often the image can be compressed with little or no loss of information. This means that the amount of filespace required to store the image is less. JPEG and GIF are examples of formats that compress images.

12. Mathematical algorithms can be used to identify particular objects in the image, such as landmarks or outlines. These in turn can be used to make measurements. A good reference is Glasbey & Horgan (1995) Image Analysis for the Biological Sciences, Wiley, Chichester.

13. Measurements, particularly of size characteristics, are often made in pixels and need to be converted into a more relevant scale.

14. The main cost associated with automated measurement using IA is usually in the preparation and imaging of plant material. It is worthwhile assessing alternative processes for obtaining images, balancing costs and quality. In some cases, further automation may be possible through the use of conveyor belts / camera systems controlled by a computer. It may be beneficial to move the imaging system out to the field and, for example, take IA measurements of leaves whilst they are attached to the plant.

15. Summary.

(i) IA is crucial to the DUS testing operations in certain crops in a number of UPOV member States and confers all of the potential advantages identified above;
(ii) research effort that concentrates on automating the recording of existing characteristics is likely to repay the costs within a few seasons. At no extra cost of recording, new meaningful characteristics can be derived;
(iii) The imaging technology and computing power now available increases the opportunities for the use of IA in the DUS testing context.

[Annex follows]

ANNEX

TWC documents concerning Image Analysis

TWC 21/7 Automatic Measurement of Pea Characteristics (UK)

TWC 21/9 Image Analysis in DUS Testing at NIAB (UK)

Examples of the application of image analysis for DUS testing in specific crops

Date	Title	UPOV Ref	UPOV TWC Session
30-Mar-94	Image Analysis in Variety Testing	TWC/12/6	12th
19-May-95	Image Recognition System for Plant Variety Testing	TWC/13/16	13th
13-May-97	Morphometric characterizing and identification of varieties of cereals by using digital image analysis of seed shapes	Annex to TWC/15/10	15th
20-May-98	Digital images in plant variety testing	CPRO-DLO	16th
09-May-01	matching Of Plant Variety Images From Different Sowings	TWC/19/6	19th
29-May-01	UPOV Questionnaire On Image Analysis In Plant Variety Testing	TWC/19/11	19th

[End of Annex and of document]