TWC/30/39
ORIGINAL: English
DATE: June 21, 2012

INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS

Geneva

TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS

Thirtieth Session

Chisinau, Republic of Moldova, June 26 to 29, 2012

SURVEY ON SOFTWARE AND HARDWARE USED FOR IMAGE ANALYSIS

Document prepared by an expert from the Netherlands

1. The Technical Working Party on Automation and Computer Programs (TWC), at its twenty-ninth session, received presentations on image analysis by experts from the United Kingdom, and Czech Republic and the Netherlands. The TWC agreed to propose the development of a questionnaire concerning software and hardware used for image analysis and invited UPOV members to make presentations on image analysis at the thirtieth session of the TWC session, in 2012 (see document TWC/30/31 "Report", paragraph 56).

2. The Technical Committee (TC), at its forty-eighth session held in Geneva, Switzerland, from March 26 to 28, 2012, agreed to the development of a questionnaire concerning software and hardware used for image analysis and that the results of the questionnaire should be presented at the TWC at its thirtieth session, to be held in Chisinau, Republic of Moldova, from June 26 to 29, 2012, (see document TC/48/22 "Report on the Conclusions", paragraph 56).

3. The TC, at its forty-eighth session, also agreed that the TWC should develop subsection 12.3 "Guidance on the use of image analysis" within the New Section 12 "Examining characteristics using image analysis" for document TGP/8 "Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability" and agreed that the new section should be prepared on the basis of the discussion on documents TWC/29/19, TWC/29/21, TWC/29/27 and TWC/29/29 (see document TC/48/22 "Report on the Conclusions", paragraph 58). The program for development of document TGP/8 is reproduced in the Annex and Appendix II to document TWC/30/3.

4. The Annex to this document contains the result and analysis of the questionnaire on image analysis issued by the Office of the Union by circular E-12/106 on April 24, 2012, which might be relevant when developing the New Section 12 "Examining characteristics using image analysis" for document TGP/8.

[Annex follows]

ANNEX

SURVEY ON SOFTWARE AND HARDWARE USED FOR IMAGE ANALYSIS

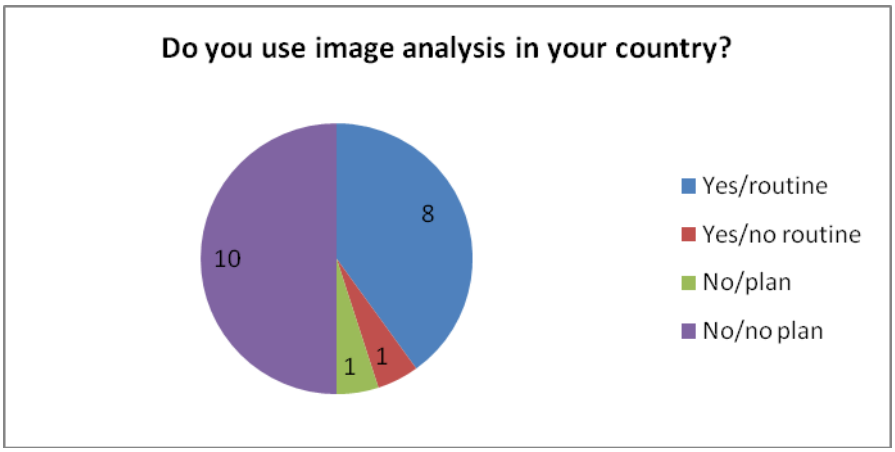
INTRODUCTION

1 A questionnaire on image analysis (see Appendix, which was an Annex to UPOV Circular E-12/106) was sent to the UPOV members on April 24, 2012. The aim of the questionnaire was to gain insight in the frequency and way of use of image analysis in the different member states.

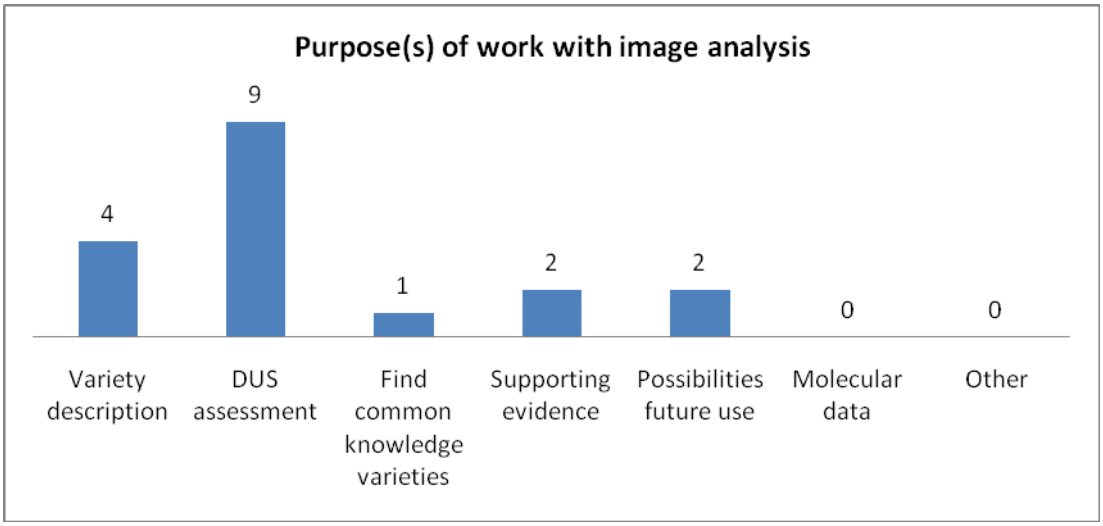
2 The questionnaire was returned by 19 member states. The United Kingdom returned two questionnaires, one from National Institute of Agricultural Botany (NIAB) and one from the Science and Advice for Scottish Agriculture (SASA), so there were 20 questionnaires in total. For sake of simplicity, NIAB and SASA are here treated as two different respondents. Results are shown in Appendix.

USE AND PURPOSE OF IMAGE ANALYSIS

3 In total eight respondents stated that image analysis is being used on a routine basis in their work, and one (Italy) non-routine. Ten respondents do not use image analysis and have no further plans to use it (see Figure 1), one country (Republic of Moldova) has plans to use it.



4 The main purpose of image analysis is for DUS assessment. It is only occasionally used for variety description, finding common knowledge varieties or supporting evidence (see Figure 2).



CROPS AND CHARACTERISTICS

5 The crops for which image analysis is being used are (in alphabetic order):

1. Barley 2. Brassica crops 3. Brussels sprouts 4. Carrots 5. Field beans 6. Flax 7. Fodder radish 8. French bean 9. Impatiens 10. Oilseed rape 11. Onions 12. Parsnip	13. Pea 14. Pelargonium 15. Red clover 16. Rice 17. Running beans 18. Seeds/grains various crops 19. Sugar beet (cotyledon) 20. Watercress 21. Wheat 22. White mustards 23. Willow (leaves)

6 Image analysis is mainly being used to measure the size and shape of seeds, leaves and roots/bulbs. There are two ornamental crops (Pelargonium and Impatiens) listed. Also for these crops, the characteristics are size and shape related. No characteristics were mentioned which measure color, texture or variegation patterns.

7 All respondents who use image analysis on a routine basis, use it as intermediate data for the DUS decision.

TECHNICAL ISSUES

8 Six respondents use a camera, four respondents use a scanner (one respondent uses both options). All use a regular PC or workstation.

9 Every country has its own software system. Most respondents use commercially available software or open source software which has been adopted by themselves. Only Italy uses off the shelf software. In some cases the software can be made available to other member states (under conditions). See Annex II for details.

10 The size of the data is hardly limiting with current disks. The largest database is about 300 GB.

RECORDING CONDITIONS

11 All respondents use some form of calibration for determining the size of an object. In general the lighting conditions are also standardized and verified. Since no color is measured, color calibration is not mentioned.

[Appendix I follows]

APPENDIX I

UPOV QUESTIONNAIRE ON IMAGE ANALYSIS

Please complete the following questions. You can attach a separate sheet(s) to provide a more complete answer if necessary (e.g. if you have different projects/purposes with image analysis).

Name of person answering the questionnaire: ……

Country:……

Organization……

Contact Information:
Address: ……
Tel:…… Fax:……
E-Mail: ……

I. GENERAL QUESTIONS

1. Use of image analysis in your country

- ☐ Yes
  - ☐ Routine-basis
  - ☐ Non routine-basis
- ☐ No
  - ☐ Planning to use
  - ☐ No plans to use

** If the answer to the above question is "Yes", please go to the following questions. Otherwise please just return this sheet to the designated persons shown at the bottom of the circular.*

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2. UPOV Technical Working Party(ies) and document references in which information has previously been provided:

☐	BMT	[document reference:	e.g. BMT/XX/XX]
☐	TWA	[document reference:	]
☐	TWO	[document reference:	]
☐	TWV	[document reference:	]
☐	TWF	[document reference:	]
☐	TWC	[document reference:	]
☐	TC	[document reference:	]
☐	CAJ	[document reference:	]

3. Purpose(s) of the work with image analysis:

- ☐ Variety description
- ☐ DUS assessment
- ☐ To find varieties of common knowledge to compare with candidate varieties in the DUS growing trials
- ☐ Supporting evidence in selected cases
- ☐ To evaluate possibilities of the method for future use
- ☐ Molecular data (e.g. banding patterns in electrophoresis gels)
- ☐ Other purpose, (please provide details):

4. Application of image analysis (species, characteristics, etc.)

5. Status of the image analysis data:

- ☐ Provided by breeder for information on voluntary basis
- ☐ Compulsory requirement for the breeder as part of the application
- ☐ As intermediate data to obtain information before the DUS decision
- ☐ To keep as retrievable information for use in other studies
- ☐ Other status, namely (please provide details):

6. Please provide a short indication of the costs and savings involved in applying image analysis.

7. Please provide other remarks, if any.

II. TECHNICAL QUESTIONS

* In the case of another person(s) (e.g. IT technicians) answering the following questions, please specify below the person's name, organization/title, telephone, fax number and e-mail address in order for us to contact them when necessary:

……

1. Hardware used (make, model, type, etc.) by steps:

□ To obtain images: .....

□ To keep and process data: .....

□ To show images on screen or paper: .....

2. Software used (make, title, version, etc.) by steps:

□ To obtain images:

□ To keep and process data:

□ To show images on screen or paper

3. Is the hardware/software commercially available?

(To obtain images)
□ Yes, from ……..……
□ Partially, we added own routines/macros
□ No, specifically developed
□

(To keep and process data)
□ Yes, from ……..……
□ Partially, we added own routines/macros
□ No, specifically developed

(To show images on screen and paper)
□ Yes, from ……..……
□ Partially, we added own routines/macros
□ No, specifically developed

4. With regard to the software specifically developed for you, is it also available to other UPOV members?

☐ Yes
☐ No
☐ Under certain conditions (please specify the condition below)

5. Please summarize the recording conditions (standardization of light, sampling density, camera type, calibration procedure, etc.)

6. Approximate volume of data kept (either Megabytes, or number of varieties, number of features, number of images, etc.)

7. Other remarks (if any):

NB: If you use image analysis for other work than variety testing (seed testing, checks for purity in maintenance, etc.) and you are willing to give information, please do so.

Please return the completed questionnaire no later than May 11, 2012 by e-mail to:

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[Appendix II follows]

APPENDIX II

Results of UPOV questionnaire on Image Analysis

	1.Use of image analysis				2. UPOV document	3. Purpose			
Member state	**Yes (routine)**	**Yes (not routine)**	**No (future plan)**	**No (No future plan)**		**Variety description**	**DUS assessment**	**Common knowledge varieties**	**Supporting evidence**
Czech Republic*	1				TWC/29/27		1		
Denmark*	1						1		
Georgia				1					
Germany*	1				TWO/29/17		1	1	
Ireland				1					
Israel				1					
Italy*		1				1	1		
Japan				1					
Latvia				1					
Republic of Moldova			1						
Netherlands*	1				TWC/29/29	1	1		1
Paraguay				1					
Poland*	1						1		
Russian Federation				1					
South Africa				1					
Spain*	1					1	1		
Sweden*				1					
United Kingdom (NIAB)*	1				TWC/29/19	1	1		1
United Kingdom (SASA)*	1				TWA 33/10, TWC 22/7, TWC 26/21 REV, TWC 29/19 (Imag-in), TWC 19/6 (Visor)		1		
United States of America				1					

*) Respondents in grey area have provided more information. See next pages.

Czech Republic

Application:

- Pea: leaves, stipules, standards, sepales
- Oilseed rape: petals, cotyledons

Technical

1. Hardware (camera)	**1.Hardware (for processing)**	**1. Hardware (for displaying)**		
Sceye 3rd generation, proprietary light system	common PC	common PC		
2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
Sceye	Matlabcomputational system, core + Image analysis toolbox (http://www.mathworks.com/)	outputs of Matlab are saved as common image files, no special software is required	Capture: http://www.sceye.eu/en/products/product-history. Process: partially, added own	No

5. Recording conditions	**6. Volume of data**	**7. Other remarks**
Image obtained in dark chamber, resolution 300 pt, calibration using coin.	Per year: Pea 5 GB, Oil seed rape 20 GB.	Image analysis in the Czech Republic is still under development, primary goal: resting suitable characteristics for pea and oil seed rape

Denmark

Application:

- Rape seed: cotyledon, petals and siliqua
- Barley: ear length, ear length of awns
- Wheat. ear length

Cost/saving:
Total cost for hard and software of applying image analysis are approximately 20.000 euros. Cost savings are mainly obtained in the image analysis of Rape seed characteristics of the siliqua. An advantage using image analysis is that it is possible to retrieve the image of the actual recorded data.

Technical:

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**
PC and flatbed scanner (plustec A3)	PC	PC

2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
Videometer image analysis progra	Videometer image analysis progra	Microsoft picture viewer	No, specifically developed	Possible to buy if you contact: http://videometer.com/ with a reference to The DanishAgriFish Agency, Department of VarietyTesting
5. Recording conditions			**6. Volume of data**	**7. Other remarks**
The material samples (cotyled on and petals) shall be fixed on paper with adhesive plastic foil. The paper has preprinted barcode, plot number etc.. The paper with the fixed the material are put in the flatbed scanner. Before image analysis of each characteristic can begin the software should calibrated using a calibration sheet from the developer			Approximately 14 Gb per year	

Germany

Applications:

- Pea, pelargonium, impatiens, willow (leaves)
- Rape, mustard, fodder radish (leaves, flowers)
- Red clover (Cotyledon leaves, first leaves)

Costs/savings:
Depending on crop and object savings are higher than costs.

Other remark:
There is a need for a programmer with special know how (at least part time). It is possible to scan images at first and to make measurements later when There is more time therefore.

Technical:

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**
flatbed scanner, digital camera	HP workstation xw4400	19" monitor

2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
standard software (scanner, digital camera)	SCIL-Image with self-programmed routines	JAVA program to retrieve images from database	Recording: Yes, from HP and Canon. Process: no. Display: partially	No

5. Recording conditions	**6. Volume of data**	**7. Other remarks**
Scanner: scan calibration circle (Ø12cm) to get the resolution we don't use the color information digital camera: flash (ring flash) and background light	2011: 80 GB image data (14.300 files)	

Italy

Application

- Rice: grain size

Costs/savings:
Cost of system (software+scanner) € 8000.

Technical:

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**
Scanner EpsonPerfection V7000	PC	Normal monitor

2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
Winseedle 2010a	Winseedle 2010a	Winseedle 2010a	Yes, Regent instruments	Commercially available

5. Recording conditions	**6. Volume of data**	**7. Other remarks**
Winseedle comes with an optical scanner and a special lighting system that minimizes shadows		

The Netherlands

Applications:

- Flax : length, width of seed; Under contruction: length, width and ratio length/width of boll
- Sugar beet: length, width, area cotyledons:
- French beans and Running beans: length (excluding beak), width, total length and degree of curvature of pod; length of beak
- Pea: length, width, degree of curvature of pod
- Carrot: length, max. width, ratio length/width, width of crown, form factor, mean width, ratio width/length of root; Under construction: root shape

Technical

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**
D90 + AF-S Nikkor 18-105mm/3.5-4.5	HP Compaq	HP Compaq

2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
NKremote 1.2 software for Windows	ImageJ with custom made plugin. Windows Excel, Genstat for statistical analysis	Microsoft Office Picture Manager	Camera hardware/software commercially available; Processing: ImageJ specifically developed. Windows Office and Genstat commercially available (own routines added)	To be discussed

5. Recording conditions	**6. Volume of data**	**7. Other remarks**
Calibration with use of calibration disc. Standardization of light – variable per crop, determination of the exposure of the photographed objects (shutter time, diaphragm and the quantity of light) is based on the histogram which is available via the software (NKremote) for the camera. Specific requirements per crop such a orientation of the objects, e.g. carrot all carrots need to be oriented horizontal.		

Poland

Applications:

- Our application is measuring 8 characteristics of oilseed rape and white mustard using scanned bitmap pictures. Results are written to database

Technical:

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**
HP Scanjet 4850		

2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
HP Software	Skaner-Sten	Skaner-sten	Process and display: specifically developed	No

5. Recording conditions	**6. Volume of data**	**7. Other remarks**
Calibration: we have to scan the model of colour and size and test it using “Skaner” application.	about 1000 images per year, (6GB per year)	

Spain

Applications:

- characteristics of grain (length and width) in rice, chickpea, etc

Technical:

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**
COLOR VIDEO CAMERA; MODEL: JVC TK-C1481B	COMPUTER: DELL DIMENSION DIM5000, INTEL PENTIUM4 3GHZ, 256 MB RAM	LCD MONITOR; DELL E1705C

2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
MIP 4 ADVANCED 5.01.02	MIP 4 ADVANCED 5.01.02	MICROSOFT EXCEL 2007	Yes, from Digital Image Systems (DIS)	No

5. Recording conditions	**6. Volume of data**	**7. Other remarks**
LIGHT= 2 36W SAMPLING DENSITY: 12 – 50 grains for variety CAMERA TYPE: color video camera CALIBRATION PROCEDURE: We use a ruler as reference and we follow the calibration instructions of the program.	approx 50 KB per variety	

Sweden

Remark:

We are using a seed scanner for analysis of "other species" in cereals. This machine uses image analysis (a camera connected to a computer with programmes for the different cereal species) for distinguishing between the seed in the sample and other seeds. In a sample it sorts out around 10% of the seeds, both of other seeds and seeds that are somehow considered not OK, so instead of manually going through 1000 gr the analyst can go through around 100 gr. This saves a lot of time. The scanner can be loaded with up to 30 samples and works even during nights.

United Kingdom (NIAB)

Applications:

- Oilseed.rape – cotyledon.measurements
- Oilseed.rape – siliqua.measurements
- Oilseed.rape – flower.measurements
- Field.bean – leaf.measurements
- Field.bean – siliqua.measurements

Technical:

1. Hardware (camera)	1. Hardware (for processing)	1. Hardware (for displaying)
Digital SLR (Olympus E-1 camera), Kaiser R2-CP Image Capture Set	Optiplex 788, quadcore with 64 Bit operating system	Dual PC monitors

2. Software (for recording)	2. Software (for processing)	2. Software (for displaying/printing)	3. Commercial availability	4. Available to other members?
Bespoke program Analysis application written in C++ and Olympus Studio Controller	Bespoke program Analysis application written in C++ and Olympus Studio Controller	Bespoke program Analysis application written in C++ and Olympus Studio Controller	No	No

5. Recording conditions	6. Volume of data
The Digital System is based on a digital camera using 2 11w lights @ 6000k which equate to natural light. The camera is suspended above a level surface. A reference object is incorporated into every picture. The IA program links with the Olympus studio Controller. The controller has special routines to handle camera aperture white noise etc. The linkage program has been specifically adapted by a consultant to allow menu driven options for each crop and to allow the entry of plot numbers. Once the controller has taken a picture the file is downloaded and re- opened by the IA program running in the background. The IA program will automatically analyze the picture and store the results in a data file. This allows the user to move any touching or irregular objects, thus equating to a live system. However the Controller can be used in isolation, storing the images to be batch processed at a later time. Once all plots have been photographed and analyzed via the batch process, thumbnail images can be examined and any outliers can be removed.	300 GB

United Kingdom (SASA)

Applications:

- Pea - stipule.measurement, petiole.measurement, pod.measurement, peduncle.measurement, leaflet.measurement, seed.shape.measurement,
- Parsnip - root.measurement,
- Brassica.crops - cotyledon.measurement,
- Brussels.sprout - sprout.measurement,
- Watercress -foliage.measurement

Costs/savings:
Automated image measurements perform at least as well as manual measurements. Overall costs between manual (more recording) and imaged (more collection) measurements are about the same – but IA enables measured characters to be recorded which could not be done manually (e.g. leaflet area). Image library becomes available 1) For reference; 2) For data checking 3) for subsequently developed characters

Other remark:
We have downloaded a copy of the freely available Image-J software and have used it to investigate the possibility of assessing seed shape in large seeded crops but as yet we have not used this method in relation to variety testing.

Technical:

1. Hardware (camera)	**1. Hardware (for processing)**	**1. Hardware (for displaying)**		
Canon EOS 450 DSLR (lab) Nikon D700 DSLR (studio)	SASA network	SASA network PCs (Dell) and printers (various		
2. Software (for recording)	**2. Software (for processing)**	**2. Software (for displaying/printing)**	**3. Commercial availability**	**4. Available to other members?**
Canon	Imag-in' Automatic Measurement Program (Biomathematics and Statistics Scotland) and 'Portfolio' v8.5 image database (Extensis).	Portfolio	camera and display yes, processing software no	No
5. Recording conditions			**6. Volume of data**	
The Digital System is based on a digital camera using 2 11w lights @ 6000k which equate to natural light. The camera is suspended above a level surface. A reference object is incorporated into every picture. The IA program links with the Olympus studio Controller. The controller has special routines to handle camera aperture white noise etc. The linkage program has been specifically adapted by a consultant to allow menu driven options for each crop and to allow the entry of plot numbers. Once the controller has taken a picture the file is downloaded and re- opened by the IA program running in the background. The IA program will automatically analyze the picture and store the results in a data file. This allows the user to move any touching or irregular objects, thus equating to a live system. However the Controller can be used in isolation, storing the images to be batch processed at a later time. Once all plots have been photographed and analyzed via the batch process, thumbnail images can be examined and any outliers can be removed.			300 GB	

[End of Appendix II and of document]