UPOV
International Union for the Protection of New Varieties of Plants

E

Technical Working Party on Testing Methods and Techniques **TWM/3/28**

Third Session
Beijing, China, April 28 to May 1, 2025

Original: English
Date: April 28, 2025

PHENOTYPING CONCEPT FOR STRENGTHENING THE PLANT VARIETY PROTECTION CHAIN VIA COMBINED USE OF IA&AI

Document prepared by an expert from Hungary

The annex to this document contains a copy of a presentation “Phenotyping concept for strengthening the plant variety protection chain via combined use of IA&AI”, to be made by an expert from Hungary, at the third session of the TWM.

[Annex follows]

Phenotyping concept for strengthening the plant variety protection chain via combined use of IA&AI

DR. SZANI Zsolt, Nébih HUNGARY
szanizs@nebih.gov.hu

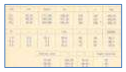
TWM/3, UPOV 28 April 2025

1

GREAT STRIDES IN FRUIT VARIETY EXAMINATION

NATIVE **POMO**LOGY

POMOGRAPHY: XVIII-XIX c. → systematization

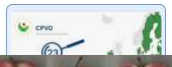


POMOMETRY: XX c. → standardisation

POMOGENETICS: late XX c. → molecular level

PAI: **POMO**LOGY + AI beginning XXI c. → human-like ability of machines

Where should the plant variety examination position itself in the AI age?



2

CHALLENGES IN PHENOTYPING

- WELL-KNOWN RISKS OF PHENOTYPIZATION: influencing factors, other than genotype
- *Fenotypical description = genotype × enviroment × human factor*

3

AUTOMATISED FENOTYPING

4

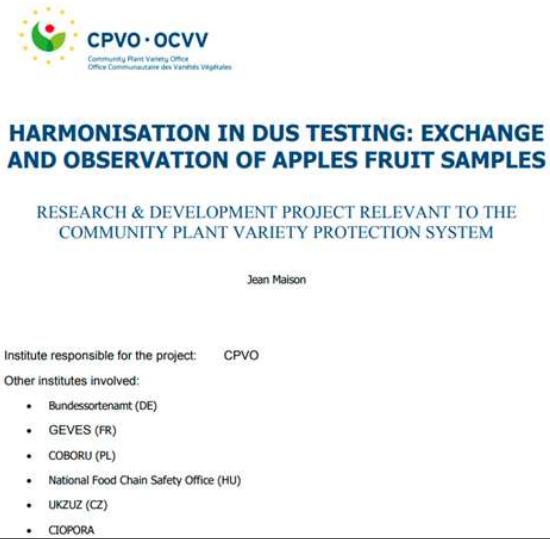
TECHNICAL PRECEDENT

- Community Plant Variety Office (CPVO) has identified a technical challenge:
  - based on more than 20 years of experience (1995 - 2018) and
  - hundreds of applications,
- **apples**
  - large number of candidate varieties ,
  - often very similar,
  - tested in different geographical regions across the EU.
- the quality of the descriptions has particularly importance in such a case
- phenotype observation is influenced by the interaction of genotype × environment × **human factor**.
- one of he answer in the UPOV system was the ring test
- In the latter period, mainly CPVO organizes ring tests and expert days.
- in 2018 R&D project relevant to the Community Plant Variety Right (CPVR) system: **HARMONISATION IN DUS TESTING: EXCHANGE AND OBSERVATION OF APPLES FRUIT SAMPLES**

5

CPVO R&D project: Harmonisation in DUS testing: exchange and observation of apples fruit samples

- Bundessortenamt (DE), COBORU (PL), GEVES (FR), Nébih (HU), UKZUZ (CZ), CIOPORA
- Period: I – XII. 2018
- 18 apple varieties



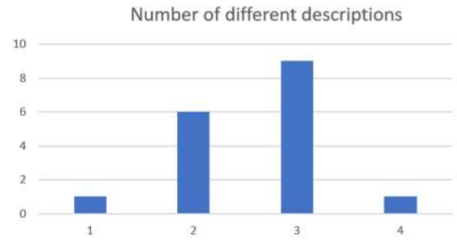
6

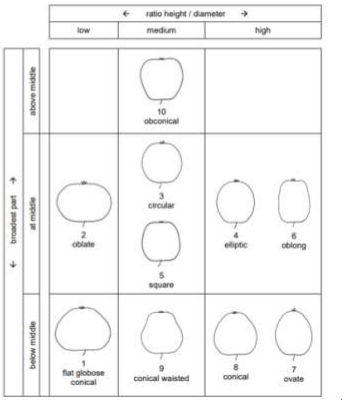
CPVO R&D project: Harmonisation in DUS testing: exchange and observation of apples fruit samples

Source: J. Maison, CPVO, Angers, 16 May 2023

Image analysis as supporting evidence

- Harmonisation of the implementation of the protocol
  - ✓ Characteristic fruit: general shape





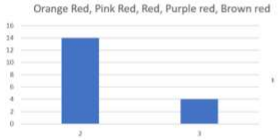
7

CPVO R&D project: Harmonisation in DUS testing: exchange and observation of apples fruit samples

Source: J. Maison, CPVO, Angers, 16 May 2023

Image analysis as supporting evidence

- Harmonisation of the implementation of the protocol
  - ✓ Fruit: hue of over colour – with bloom removed



  - ✓ Fruit: ground colour

  - ✓ Fruit: pattern of over colour

only solid flush

solid flush with weakly defined stripes

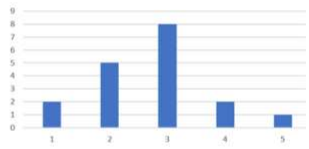
solid flush with strongly defined stripes

weakly defined flush with strongly defined stripes

only stripes (no flush)

flushed and mottled

flushed, striped and mottled



⇨ Some more objective measurements badly needed!

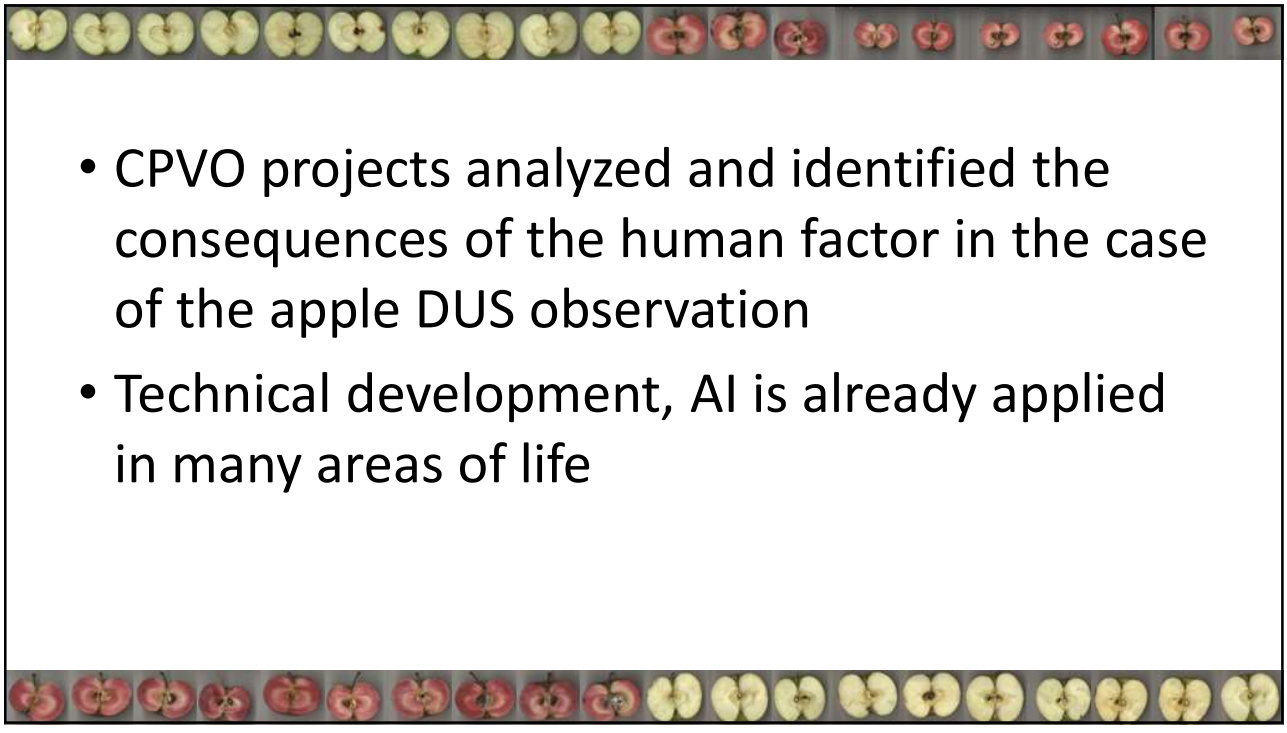
8

CPVO R&D project: Harmonisation in DUS testing: exchange and observation of apples fruit samples
Source: CPVO, Angers, 16 May 2023

Image analysis as supporting evidence

- Need for supporting evidence when distinctness is established on the basis of characteristics observed visually, in particular colours and shape.
  - ⇨ Image analysis could provide such supporting evidence providing objectivity, making it in particular possible to measure characteristics observed so far visually and establish thresholds
- Added value:
  - ✓ Time savings for DUS examiner
  - ✓ Scaling up observations
  - ✓ Harmonization

9

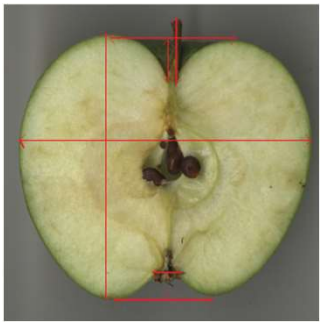


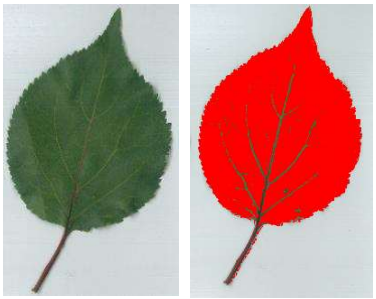
10

IMAGE ANALYSIS

- QN characteristics:

distance, area, green color component





11

AIM: to study the potential of AI in the DUS examination

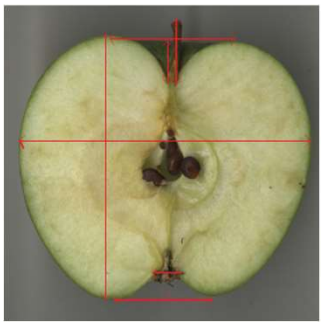
- Approach:
  - the principle: a handful every day
  - characteristics from CPVO Technical Protocols
  - use of common technical tools,
  - results: option for clear verification,
  - predictable duration,

- general technical parameters:
  - 15 apple varieties
  - 10 fruit images / variety
  - 200 dpi (the known dpi size is important),
  - jpg format (png would be optimal for less data loss),
  - office scanner: low to mid-range

12

IMAGE ANALYSIS

- When the boundaries of the object to be measured are not sharply separated from their surroundings?



- The combined use of **AI & IA**

13

AUTOMATISED FENOTYPING

14

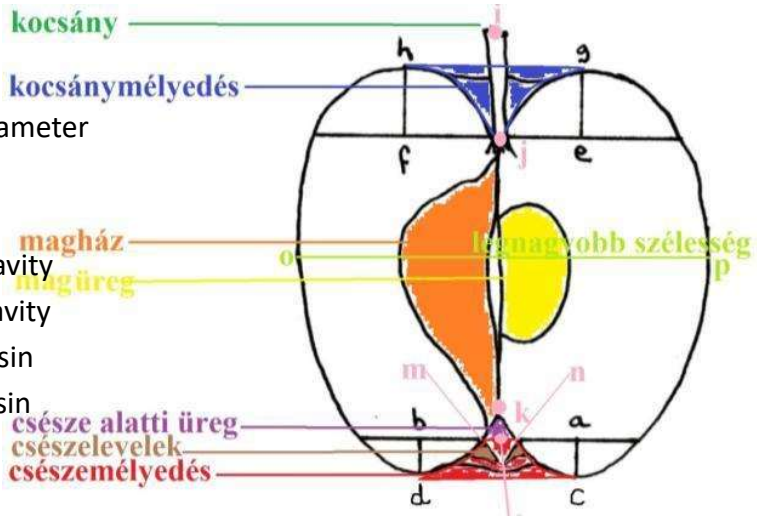
TRIAL DESIGN

- Pilot species: apple
- Protocol: CPVO-TP 14/02
- Plant part: fruit
- Selection of varieties:
  - fruit flesh color (anthocian ±),
  - fuit size (small / large),
  - Symmetry (sym. / asym.)
- Type of char.: QN
- 9 characteristics
- 11 nominated pomological point

15

TRIAL DESIGN

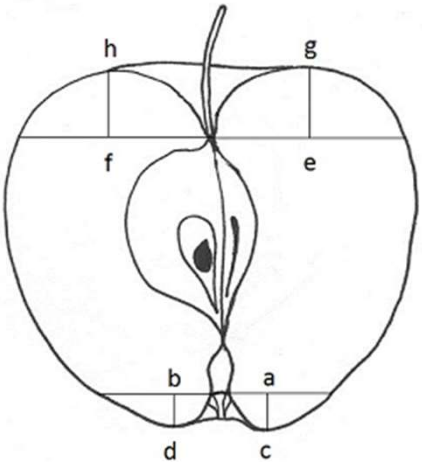
- Characterictics:
  - Char.25: Fruit: height
  - Char.26: Fruit: diameter
  - Char.27: Fruit: ratio height / diameter
  - Char.31: Fruit: size of eye
  - Char.46: Fruit: length of stalk
  - Char.48: Fruit: depth of stalk cavity
  - Char.49: Fruit: width of stalk cavity
  - Char.50: Fruit: depth of eye basin
  - Char.51: Fruit: width of eye basin

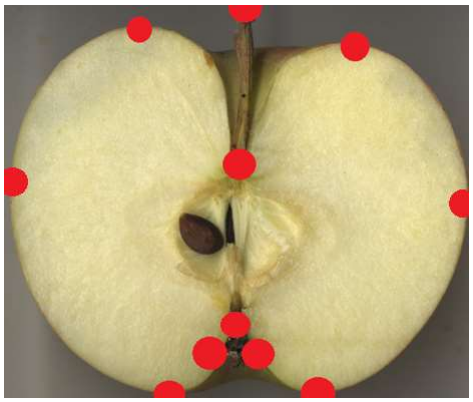


16

ZERO HYPOTHESIS:

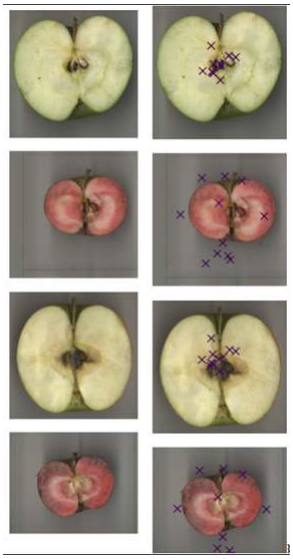
• CAN THE AI IDENTIFY THE MAIN POMOLOGICAL POINTS ON AN APPLE FRUIT?





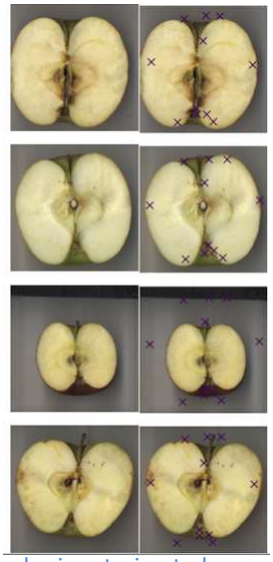
17

1. stage



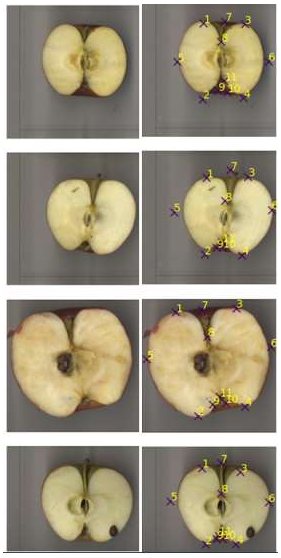
the neutral net is first disturbed by the flesh colour

2. stage



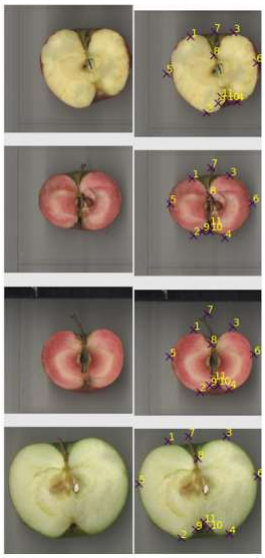
developing, trying to learn sizes, however the small apple is not yet recognised well

3. stage



large fruit is well recognised, small fruit is not recognised

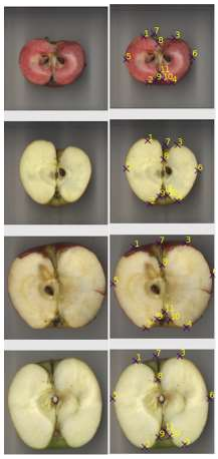
4. stage



has improved, small fruit is recognised, but asymmetry is not yet managed

18

current status, after: - re-calibration of neutral mesh 10 times
- 10.000-50.000 training cycles / re-calibrat.



flesh colour, fruit size and asymmetry are managed

- What benefits do we expect:
  - transfer current DUS expert generation's experiences into AI age
  - knowledge management
  - more harmonized work
  - objectivity
  - increased description quality
  - reduction of identification time

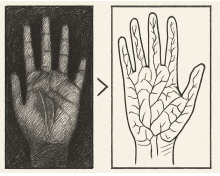
19

PLANT VARIETY IDENTIFICATION

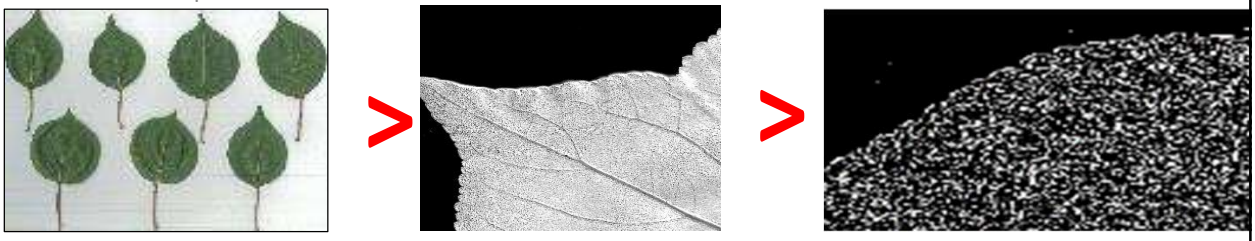
20

PLANT VARIETY IDENTIFICATION

Vein system: unique biometric pattern



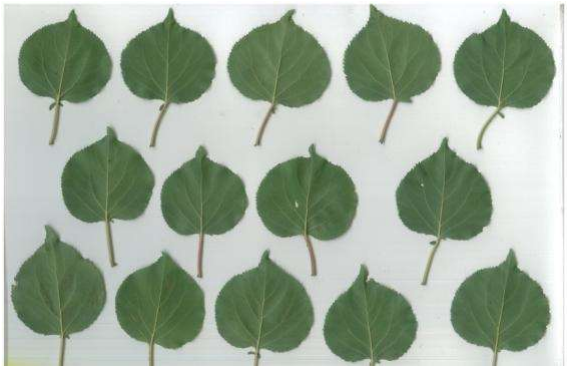
The basic idea: a biometric control system based on a key formed from a vein system, developed by a Hungarian research and development team and based on a combination of an sensorial instrument and a software.



21

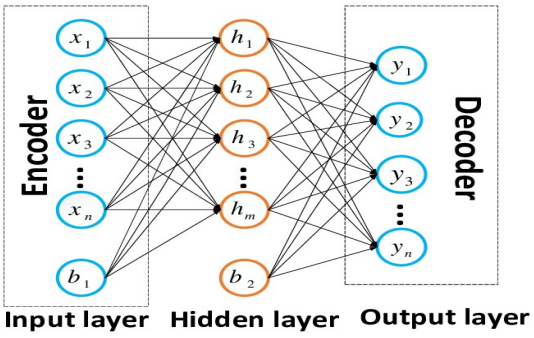
GENERAL TECHNICAL PARAMETERS

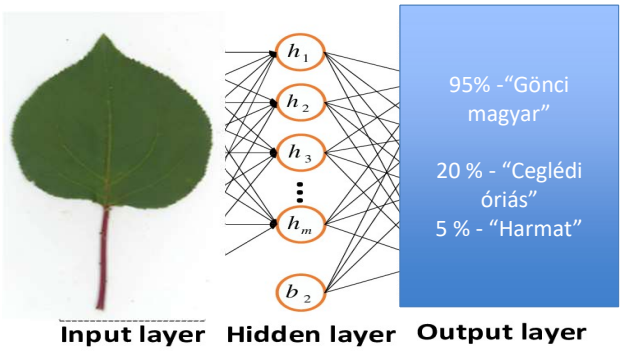
- 10 apricot varieties
- 50 leaf images / variety
- 200 dpi (the known dpi size is important),
- jpg format (png would be optimal for less data loss),
- office scanner: low to mid-range



22

How to use AI

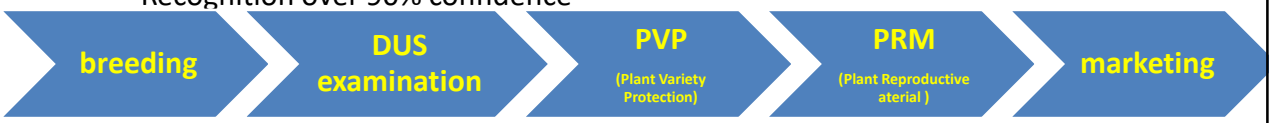




23

Preliminary results at plant variety identification

- **PRELIMINARY RESULTS**
  - first version of the learning algorithm
  - The first version of the comparison (=prefetching) algorithm has been tested
  - 10 apricot varieties were teached
  - Recognition over 90% confidence
- **POTENTIAL APPLICATION AREAS**
  - strengthening the CPVR chain
  - time- and cost effective field application



24

CONCLUSIONS OF THE STUDY on combined AI&IA

- **NEED**
  - human factor
  - knowledge management
  - different geographical regions
  - increase the sample size on optimal level
- **SHORT TERM OPPORTUNITIES,** based on primary results:
  - combined AI&IA ↑ the effectiveness of the expert
  - develop PAI on QN characteristics into final application
  - involve well-experienced technical experts in the AI learning process
  - coopertation on Examination Offices s level
  - to extend Pomological AI over QL and PQ characteristics
- **LONG-TERM PLAN**
  - mobile phone application
  - re-processing of historical data
  - study other factors, e.g. environment x genotype interaction
- **POTENTIAL APPLICATION AREAS**
  - automatised fenotyping in the DUS examination,
  - virtual ring test,
  - specialist training courses,
  - expert advise, consultation,
  - strengthening the CPVR chain

Would you have ideas, please share ...

25

26

[End of Annex and of document]