



Early forecast of apple and pear yield based on visualisation of tree crown

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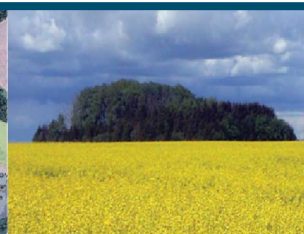
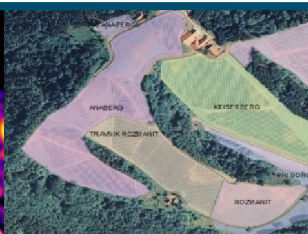
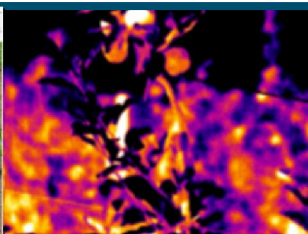
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AGRICULTURE FOR LIFE, LIFE FOR AGRICULTURE

VIRAL Workshop

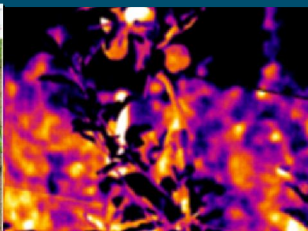
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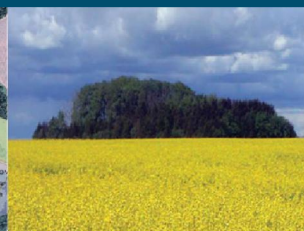
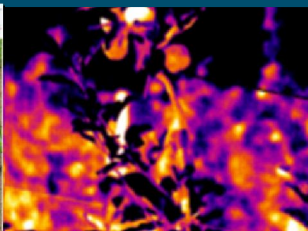
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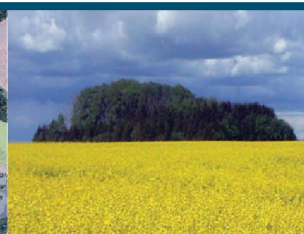
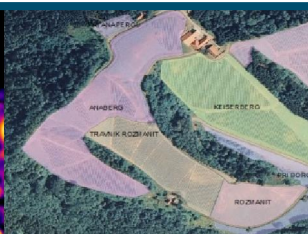
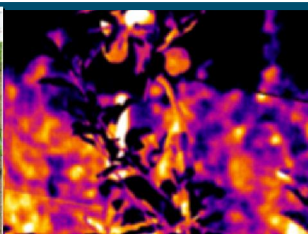
Introduction

- The goal of intensive apple and pear growing is the production of regular and abundant quantities of first-class fruits.
- Pome fruits are known on alternative bearing, which requires adjustment of work and storage capacities every year
- Manual measurements in orchards are time intensive, together with the use of growing curves enables early prediction of the yield on large uniform plantations, while smaller fruit growers are still left without this information.





- Digital technology enables faster and more objective collection and processing of data.
- Modern computer technology is already emerging in agriculture as well and it is present in fruit growing.
- Its special part - artificial vision - is already an integral part of modern fruit sorting and packaging lines,...
- However, the use of visualisation and image analysis for monitoring growth and development of fruits, with special emphasis on early yield estimation is still developing





Challenges

a) Trees are 3D shapes which needs to be captures on 2D.

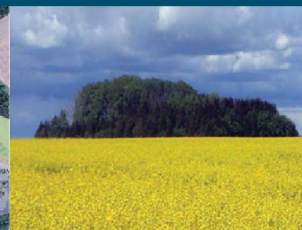
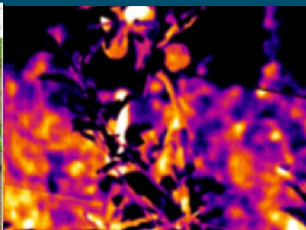
How to capture images and what is the lost of information?

b) Young fruits are small, often green coloured and covered by leaves, brenches and other obsticles

Algorithm?

c) The yield is a function of number of fruits and their weight at harvest.

Estimation?



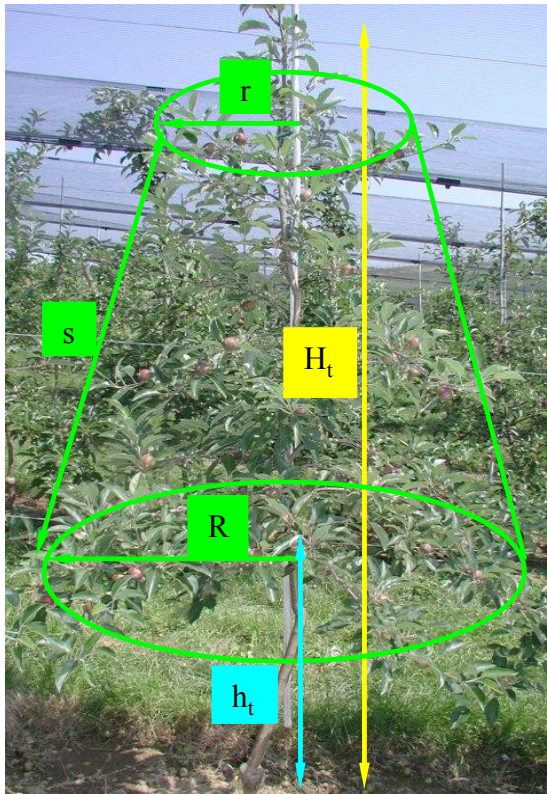


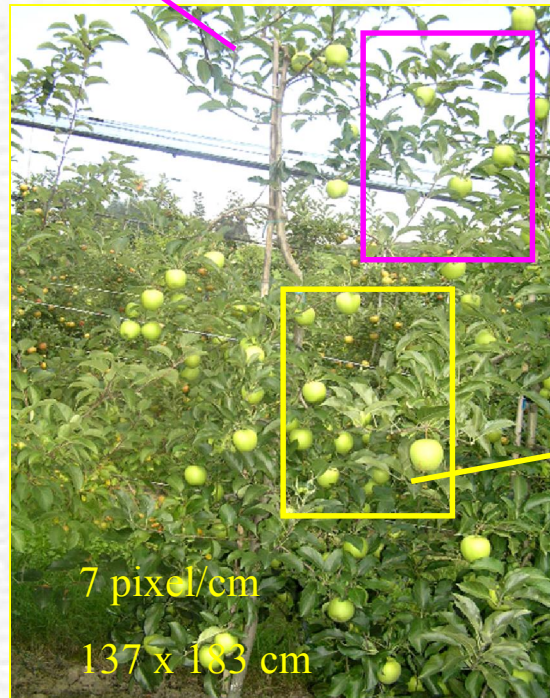
Figure 1. The majority of fruits are growing on the outside the crown, so we assume the 3D canopy as 2D plane. We are sampling only parts of surface.



Figure 2. We need to capture images perpendicular to the trees and an object with known diameter (tennis ball 65 mm)



11x



11x

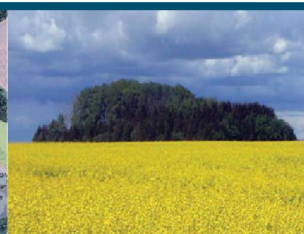
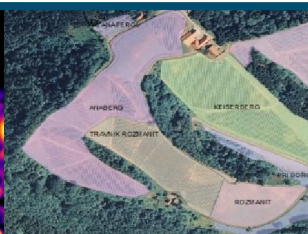
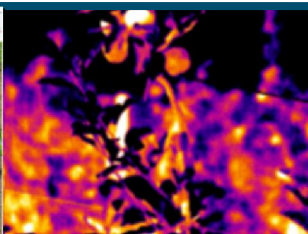
Figure 3: By changing the distance between the camera and the tree, we are changing the ratio between pixels/mm



Algorithm

Labview

IMAQ Vision only on Windows and Mac



Algorithm

FUJIYIELDhecture.VI Front Panel

File Edit Operate Tools Browse Window Help

13pt Application Font

IMAGE path
 %E:\POH.DVOR8102004\FUJITATJANA\IIIVRSTA\III73.JPG

TEMPLATE path
 %C:\Documents and Settings\Lakota\My Documents\Moje slike\TEST\KROGBIT.bmp

TEMPLATE path 2
 %C:\Documents and Settings\Lakota\My Documents\Moje slike\TEST\JABOL.MAY.bmp

REZULTAT
 %C:\Documents and Settings\Lakota\My Documents\Moje slike\JAMSEK\FUJIA-B.xls

NUMBER OF IMAGES
 34,00

start analysis

Unit
 millimeter

X Step
 2,18

Y Step
 2,18

FAKTOR
 2,18

X Resolution 2
 640

Y Resolution 2
 480

POVRšina ENE SLIKE
 2,83

Tolerance 1
 0,80

Tolerance 2
 0,30

Selection Values

Parameter
 Longest segment length

Lower Value
 10,00

Upper Value
 32,00

Interval
 Include

Parametri voćnjaka

SIRINA VRSTE m	2,60
VISINA DREVES	4,50
VISINA 1. VEJE	0,70
DOLŽINA VRST/HA	3846,15
RODNA PLOŠKEV m2/HA	29230,77
SLIKANA PLOŠKEV m2	99,05

Rezultati analize

APPLES/IMAGE	10,00
YIELD kg /IMAGE	0,30
FORECAST IMAGE kg	8,28
APPLES TOTAL	445,00
DIAMETER AVERAGE mm	32,70
YIELD IMAGES TOTAL kg	20,62
YIELD(IM) MOMENT kg/ha	6083,76
YIELD FORECAST kg/ha	23638,40

Parametri za obradu slike

Red

Lower value
 180

Upper value
 255

Green

Lower value
 0

Upper value
 255

Blue

Lower value
 0

Upper value
 255

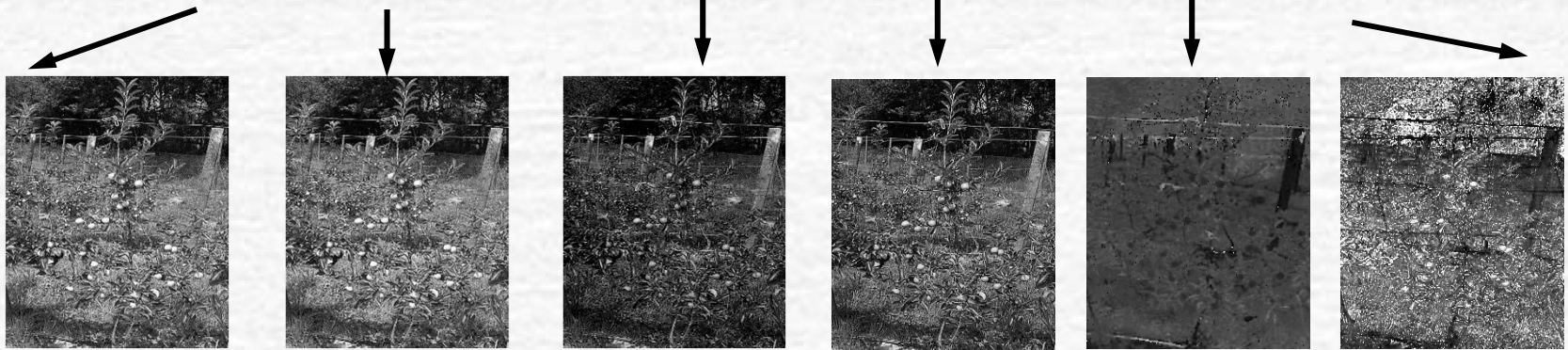
Proгноза

Figure 4: Working platform of the algorithm

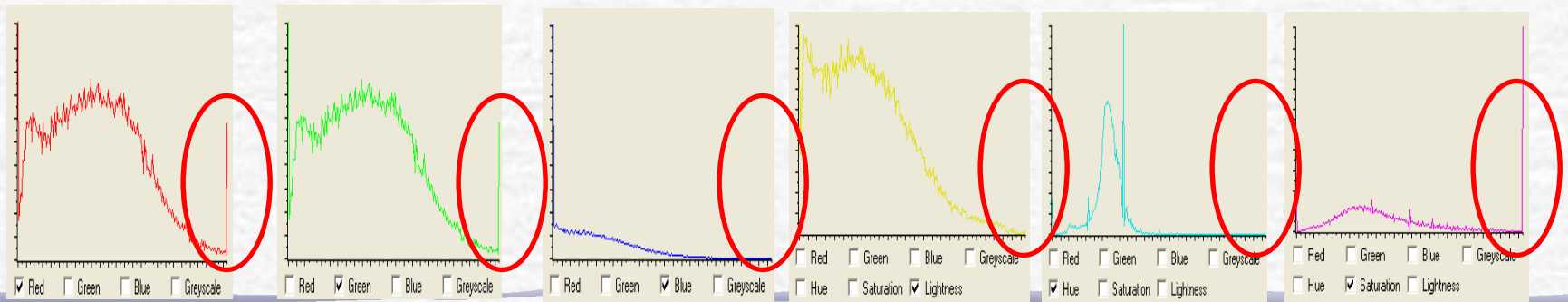
Transformation of
RGB image (top)
into its basic colour planes
Reduction of information



RGB



Red (R) Green (G) Blue (B) Intensity (I) Hue (H) Saturation (S)



Histograms

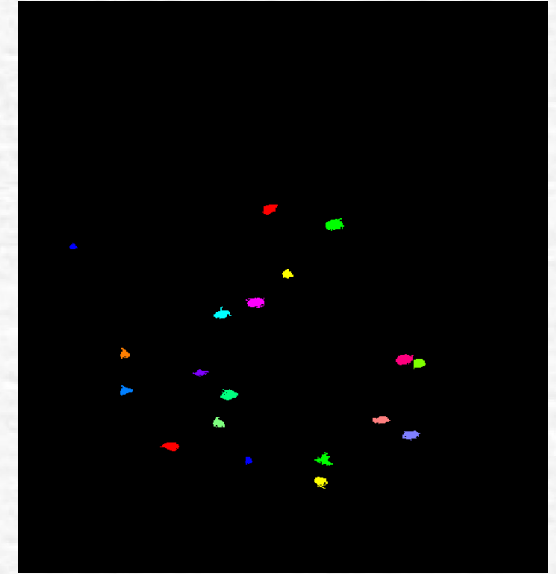
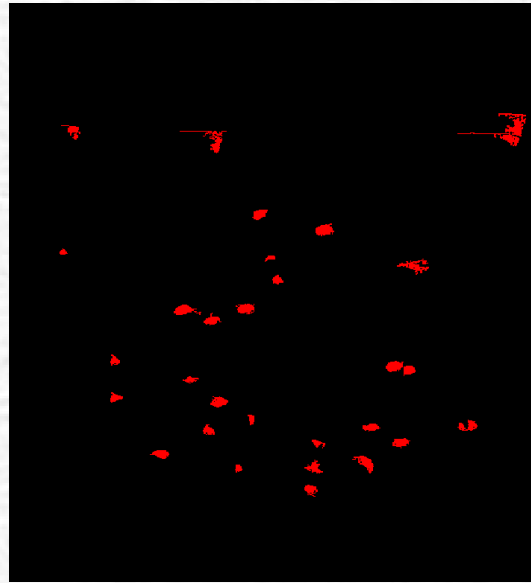


Figure 5. Binarisation after several filtering steps and application of templates

Result is a number and diameter of fruits

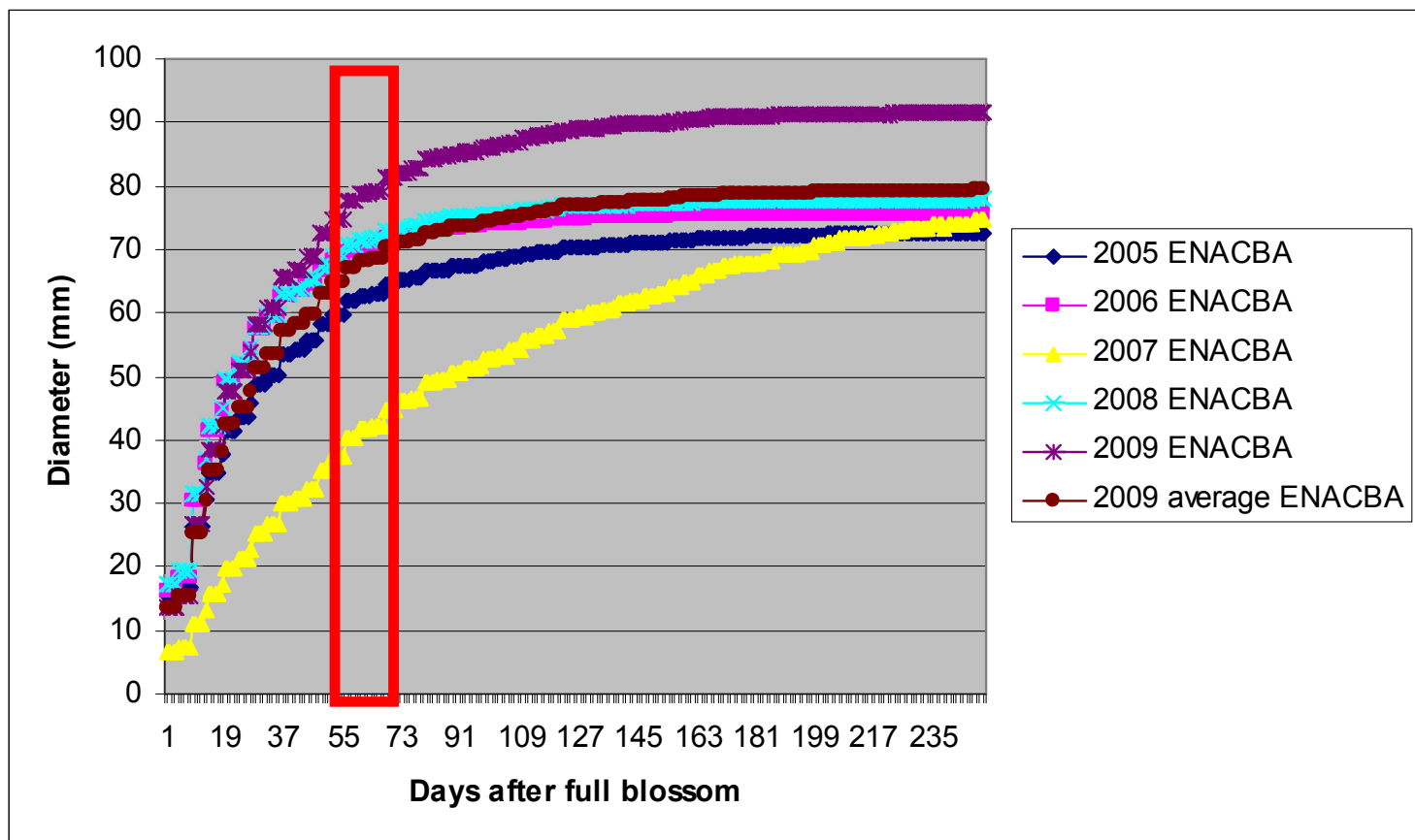
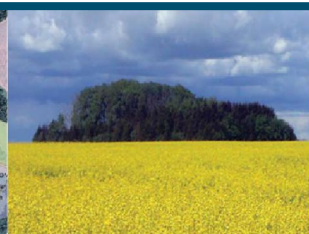
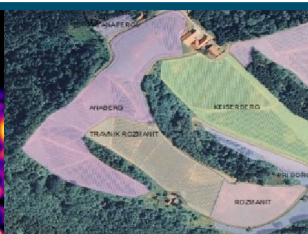
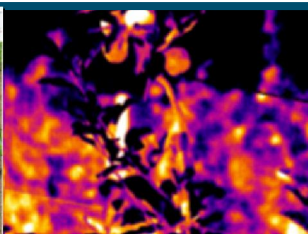


Figure 6: Sample of growing curves of 'Fuji' variety between 2005 and 2009 (Gačnik)



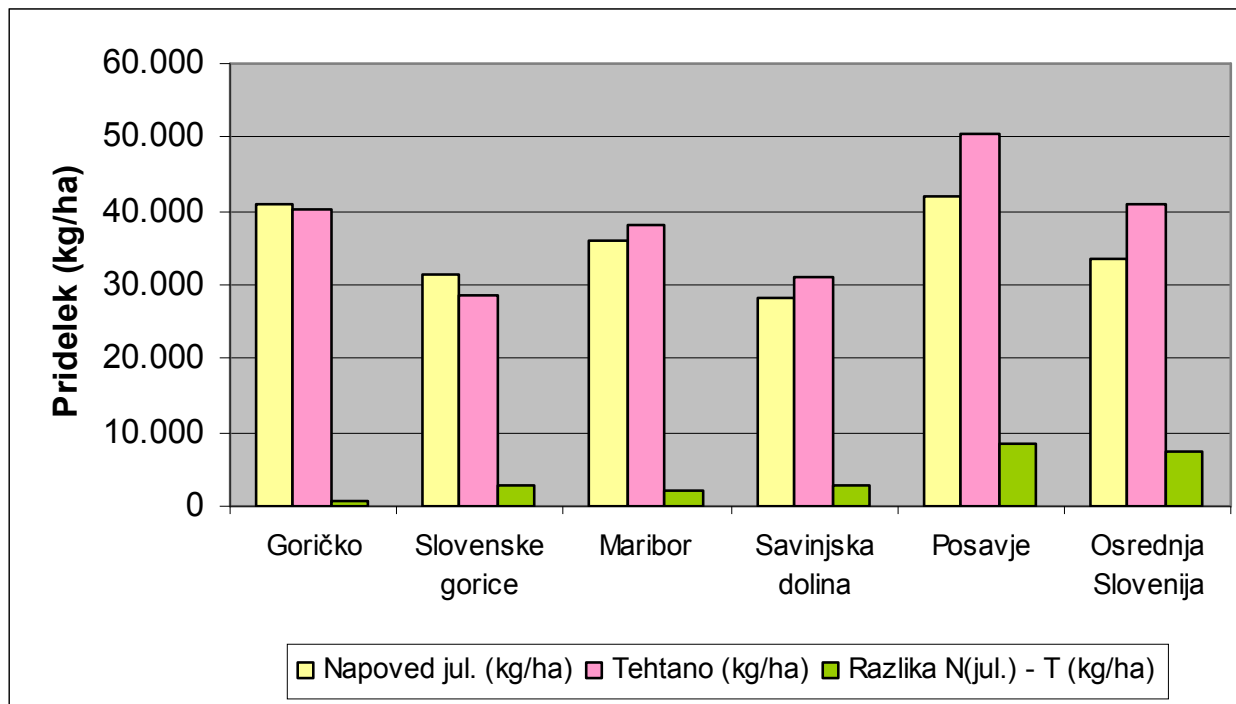
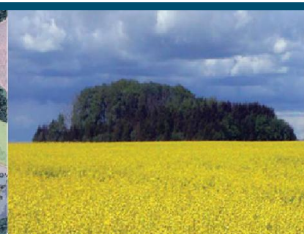
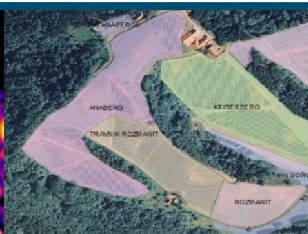
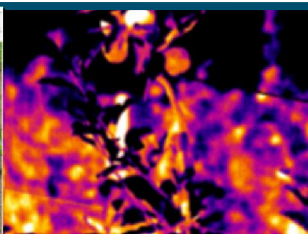


Figure 7: Results of early yield estimation for Slovenia in 2018
(green columns is a difference)



Conclusions

- Image analysis enables modelling of apple and pear fruit development and estimation of the harvested yield under orchard conditions with 90-95 % accuracy.
- Presented algorithm is used for WAPA annual statistics in Slovenia since 2004.
- It has been evaluated also in Austria, Germany, Swiss, Italy and Croatia,
- But, accurate information is not always welcome, as discrepancies between actual yields and forecasts always allow for speculation in marketing
- For broader application (individual farmers) the algorithm needs to be rewritten for Android so it can be used on smart phones or tablets.

Faculty of Agriculture and Life Sciences

Thank you for your attention

