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# Computerised X-ray Imaging for Grain Diagnostics

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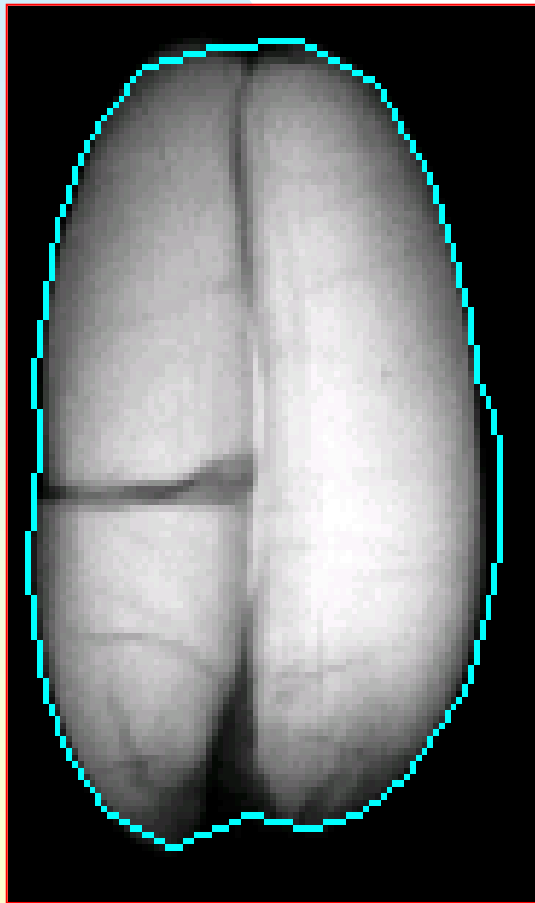
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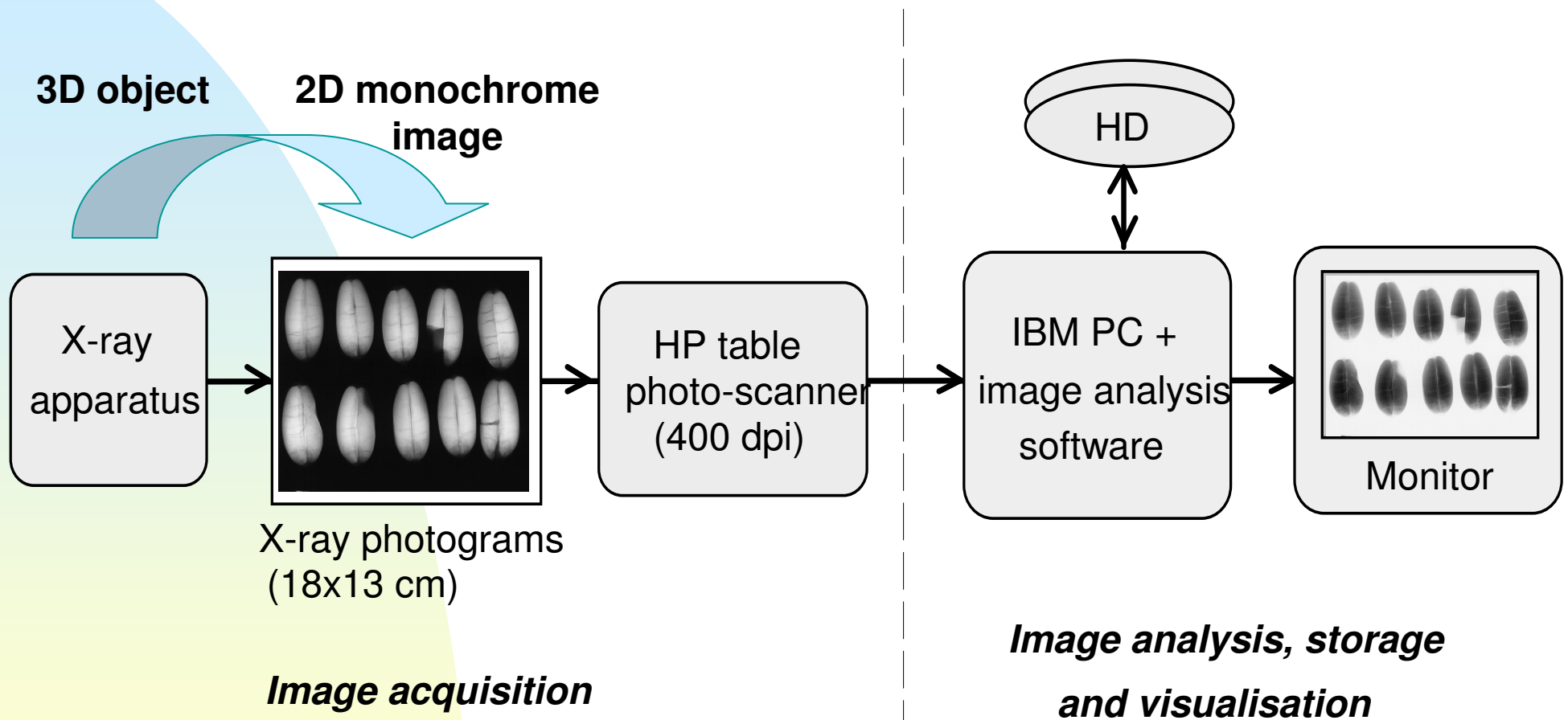
# Why X-ray imaging of grains?

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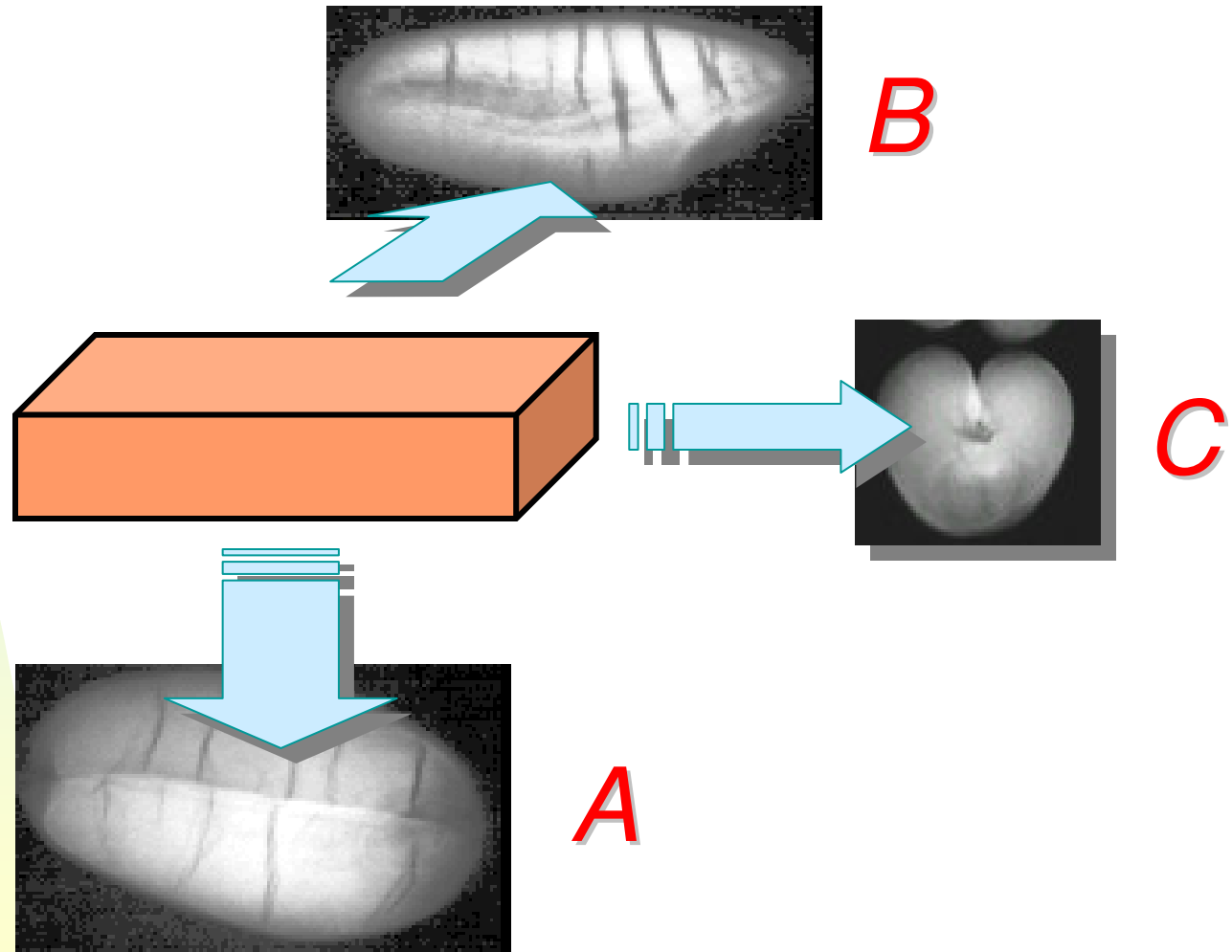
- Provides information about internal grain structure (e.g., groove profile, germ shape, kernel damages, etc.)
- Provides excellent visualisation quality (i.e., high spatial and grey scale resolution)
- Is a non-destructive diagnostic method
- Is relatively cheap

# Image Acquisition and Processing



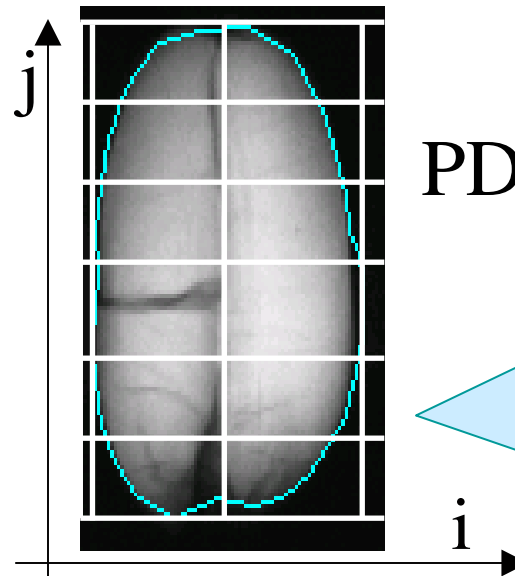
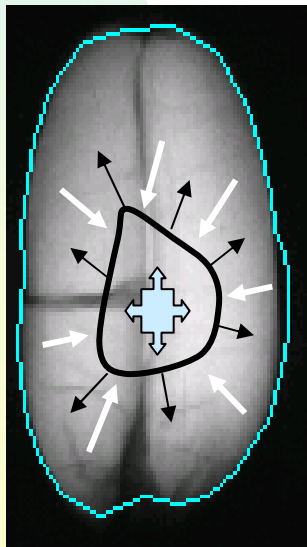
# Scanning projections

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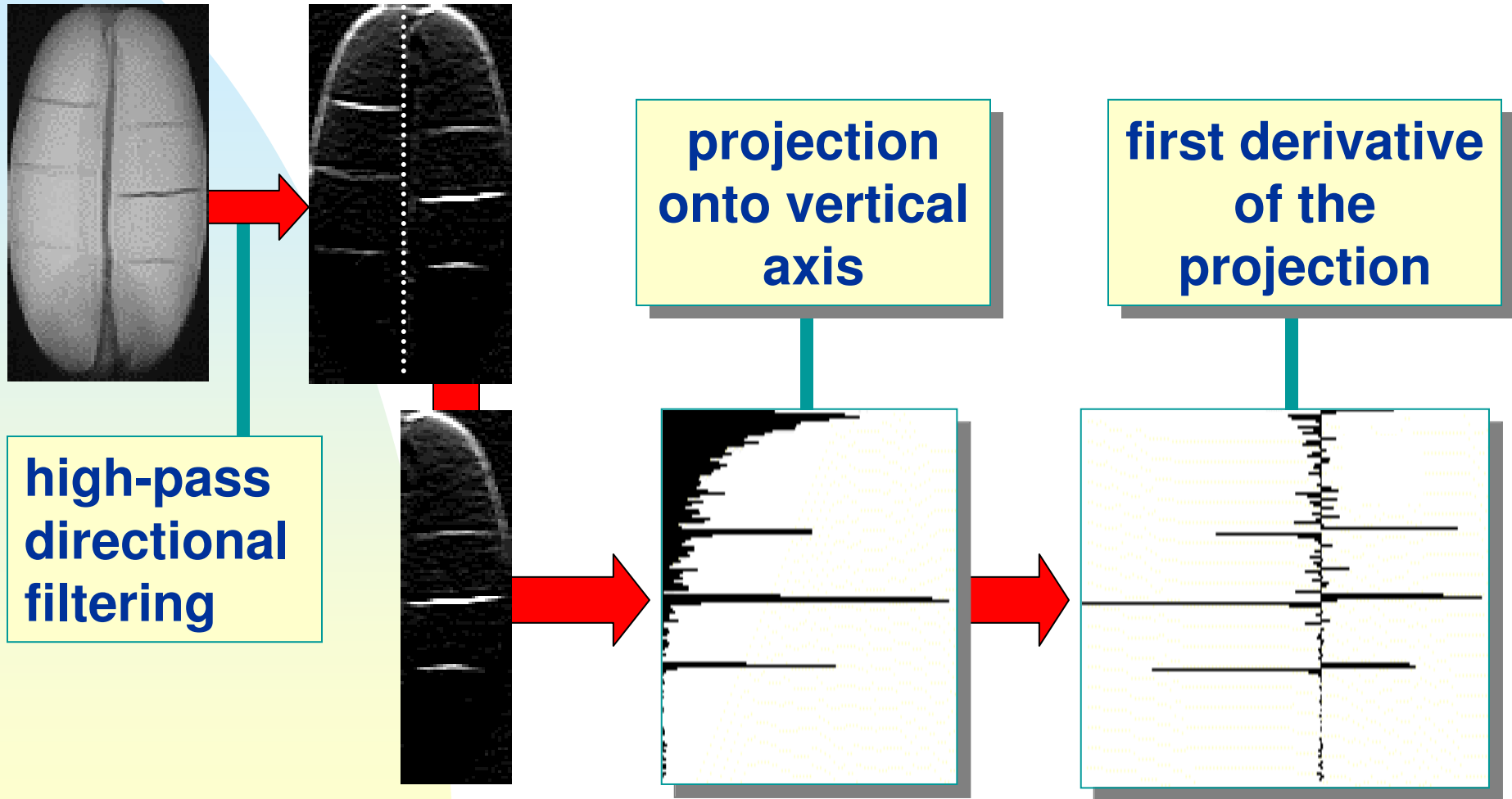
# Analysis steps of grain X-ray images

- detection of grain boundary in an image
- calculation of geometrical and statistical parameters of grain kernel
- computation of damage indices



$$PDI = \sum_i \sum_j w_j d_{ij}$$

# Quantification of kernel damages



# Automatic PDI calculation in GRAINS II

The screenshot displays the 'Analysis' window of the GRAINS II software. The window is divided into several sections:

- Image View:** A central window showing a grain image with a cyan outline and a yellow grid. Below the image are several icons for different analysis modes and a brightness slider set to 160.
- Analysis Options:** A tabbed interface with 'Analysis' selected. It contains a 'Discrete analysis' table and 'Damage Indices'.
- Discrete analysis:** A 6x2 grid of numbers. The top row is 0 0. The second and third rows are 1 1. The fourth row is 1 1. The fifth row is 1 0. The bottom row is 1 1.
- Damage Indices:** A list of metrics:
  - Overall: 9
  - Integer: 645
  - Fractional: 0,88481
  - User defined: 9
  - Continuous: 1,68572
- Grain Information:** Fields for 'Grain's code' (Z1502 -) and 'Comment' (grain from sample 25/98).
- Buttons:** 'Analyse', 'To Report', and 'Close' buttons are located at the bottom right.
- Test Mode:** A checkbox labeled 'Test Mode' is located at the bottom center.



# Software package **GRAINS** - *main capabilities*

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- Menu driven (works in Windows 95)
- Loads and displays X-ray grain images (axonometric projections, pseudo-colours)
- Measurements of main grain geometric features (e.g., area, shape factors)
- Computes image statistics (e.g., image histogram, mean, median of grain image)
- Calculates grain damage indices
- Generates spreadsheets

# Software package **GRAINS II** - *main capabilities*

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- menu driven (works in Windows 95/98/NT)
- loads and displays X-ray grain images
- **automatically calculates grain damage indices**
- generates reports (including comparisons between automatic and “manual” PDI quantification)
- features simple **IP** (Image Processing) script language
- provides easy link to **GRAINS** package

# Analysis results\*

$v_1$	$v_2$
1	1
0	0
0	0
1	1
1	0
0	0
1	1
0	1
0	0
1	1

PDI	Accuracy [%]
binary (Hamming)	84,5
Overall	91,7
Integer	95,4
Fractional	95,4

\*) for sample counting 108 annotated grain kernels

# Conclusions

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- **GRAINS** and **GRAINS II** are software packages specially developed for X-ray diagnostics of wheat kernels
  - they are result of **interdisciplinary** effort
  - **GRAINS III** can be suitable for analysis of other plant materials
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- advanced **computer vision** (i.e., *image processing + computational intelligence*)  
⇒ methods required for further advancements