Intégration de connaissance experte dans des systèmes de fusion d'informations

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LISTIC */ ESIA – Université de Savoie*

Travaux du LISTIC

- Thème central : méthodes/systèmes de fusion d'informations
  - *Systèmes **coopératifs** : informations a priori, connaissance experte,*
  - *Approche basées sur la **logique floue;***
- Extraction d'informations :
  - *Calcul d'attributs **2D, 3D, 2D+temps**,*
  - *Images **multi-composantes** (multi-spectrale, polarisation, interférométrie)*
- Application en télédétection :
  - *Images **multi-dates** (détection de changement),*
  - *Données **PolInSAR** : estimation de cohérence, classification Wishart,*
  - ***ORFEO** : Optique + Radar + Haute Résolution.*

Différents niveaux de fusion

Scène

« Decision level » : objets, cibles

→ Validation/rejet, tri, simplification…

Attributs / primitives

« Feature level » : attributs, paramètres

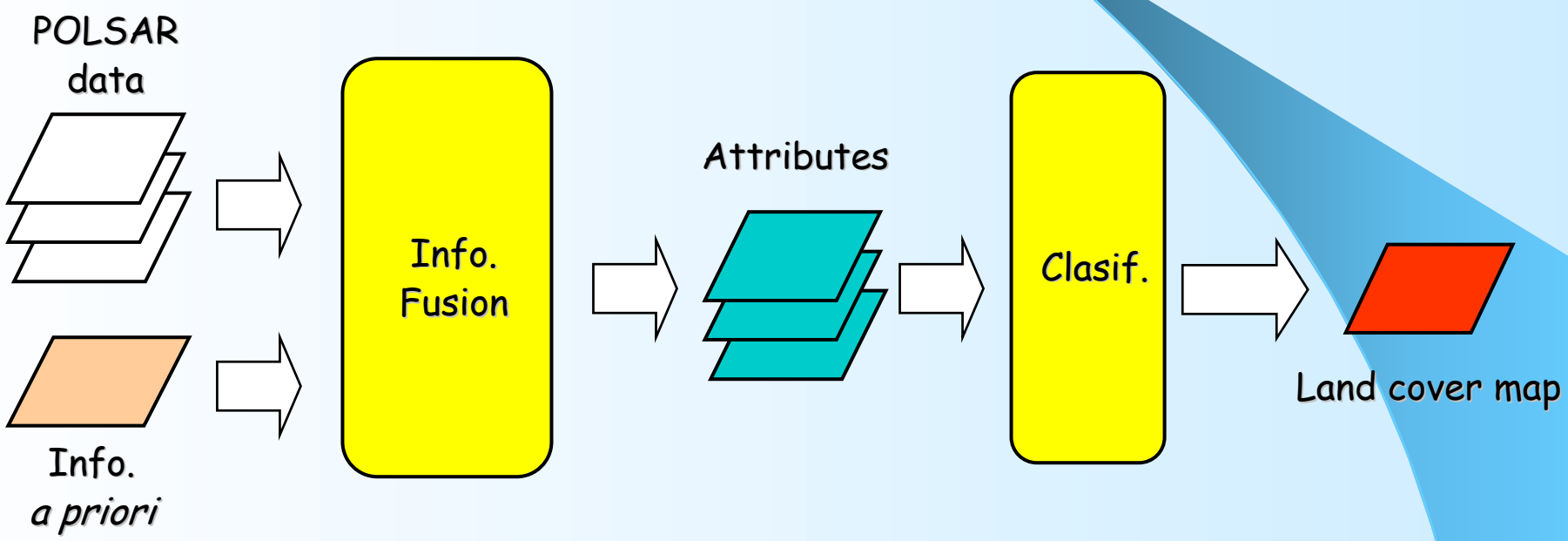
→ Classification, détections…

Pixels

« Data level » : albédo, radiométrie

→ filtrage, amélioration de résolution…

Fusion « Data level »



POL-InSAR imaging

- Three different polarization configurations $k_{\{HH,VV,XX\}}$;
- Estimation of matrix C_{pol}:

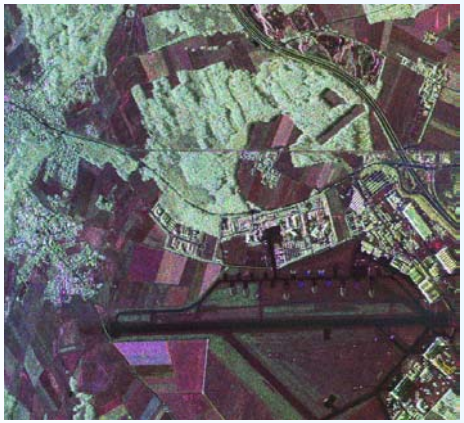
$$C_{pol} = \begin{bmatrix} [T_{11}] & [\Omega_{12}] \\ [\Omega_{12}]^{*T} & [T_{22}] \end{bmatrix}$$

Coherency matrices:

$$[T_{ii}] = \langle k_i k_i^{*T} \rangle$$

Polarimetric interferometric covariance:

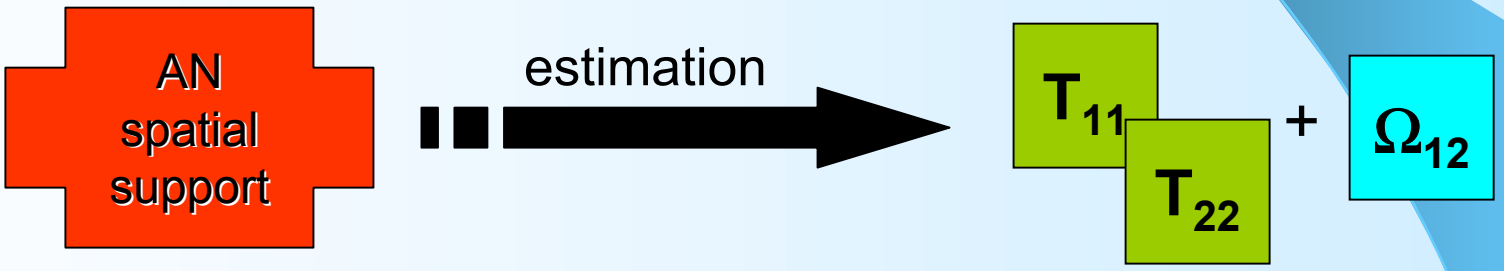
$$[\Omega_{12}] = \langle k_1 k_2^{*T} \rangle$$



- HR airborne L-band POL-InSAR images of the Oberpfaffenhofen area, Wessling, Germany;
- colored composition of diag$\{T_{11}\}$.

IDAN estimation

Principle: In each pixel (seed), a window of variable shape and dimensions is built, containing only connex pixels belonging to the same statistic population as the seed.



Goal:

- reach the number of pixels necessary for reliable complex-correlation estimation;
- preserve stationarity within estimation window;
- estimate statistical measures over the largest possible neighborhood.

IDAN estimation

original

boxcar

directional

IDAN

T_{11} intensity image filtering results [526 × 310 pixels]:

H/α/A decomposition

EIGENVECTOR DECOMPOSITION OF COHERENCY

real eigenvalues $\lambda_1 > \lambda_2 > \lambda_3$ of T_{ii}

$$P_i = \frac{\lambda_i}{\sum_{k=1}^{3} \lambda_k}$$

ENTROPY

$$H = -\sum_{i=1}^{3} P_i \log_3(P_i)$$

ANISOTROPY

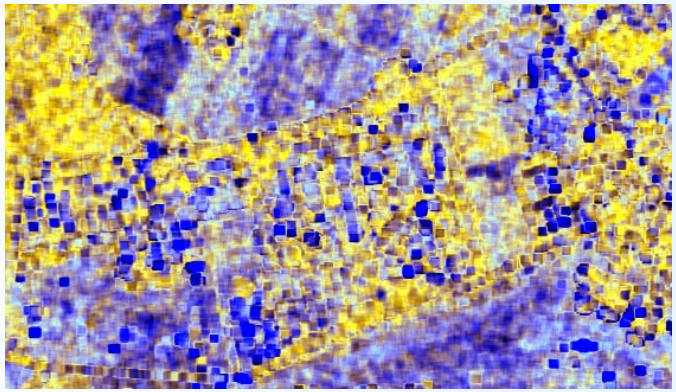
$$A = \frac{\lambda_2 - \lambda_3}{\lambda_2 + \lambda_3}$$

α PARAMETER

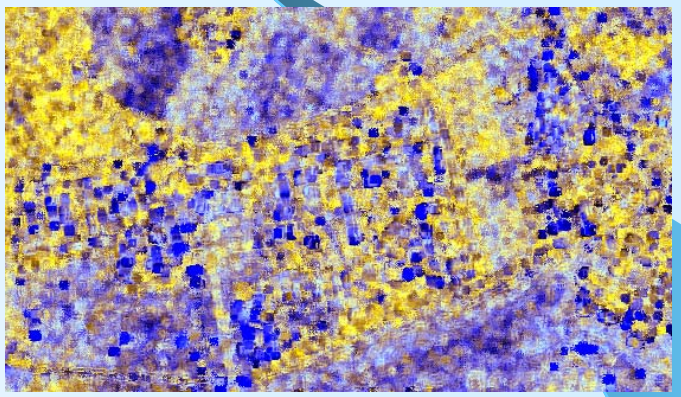
$$\underline{\alpha} = P_1\alpha_1 + P_2\alpha_2 + P_3\alpha_3$$

H/α/A decomposition

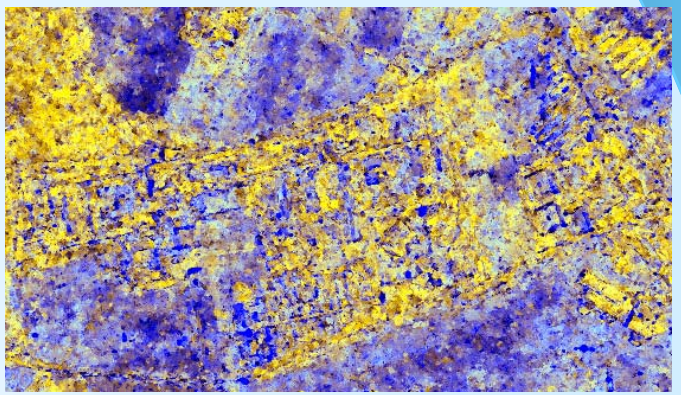
boxcar



directional



IDAN

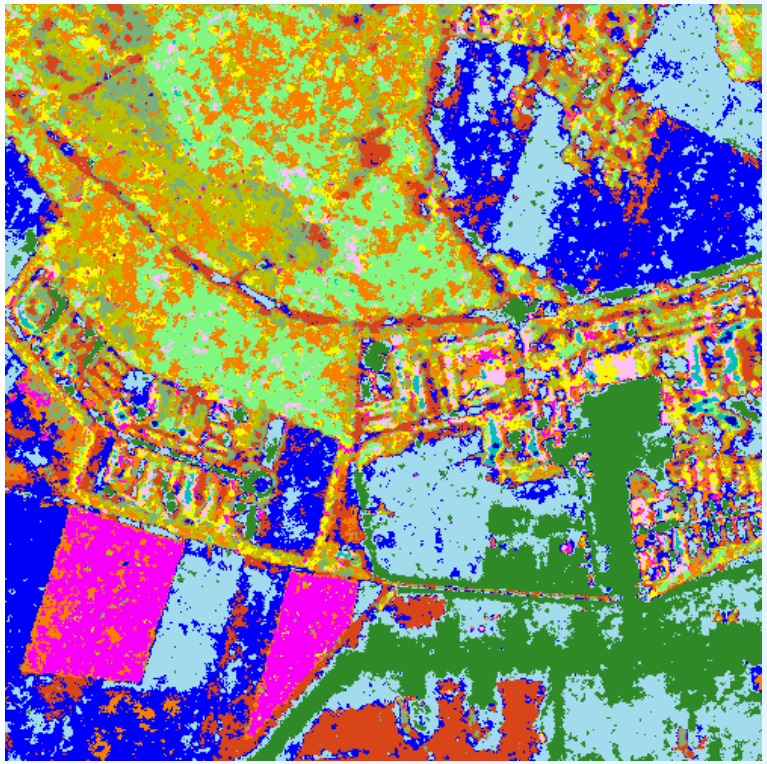


H/α/A of T_{11}

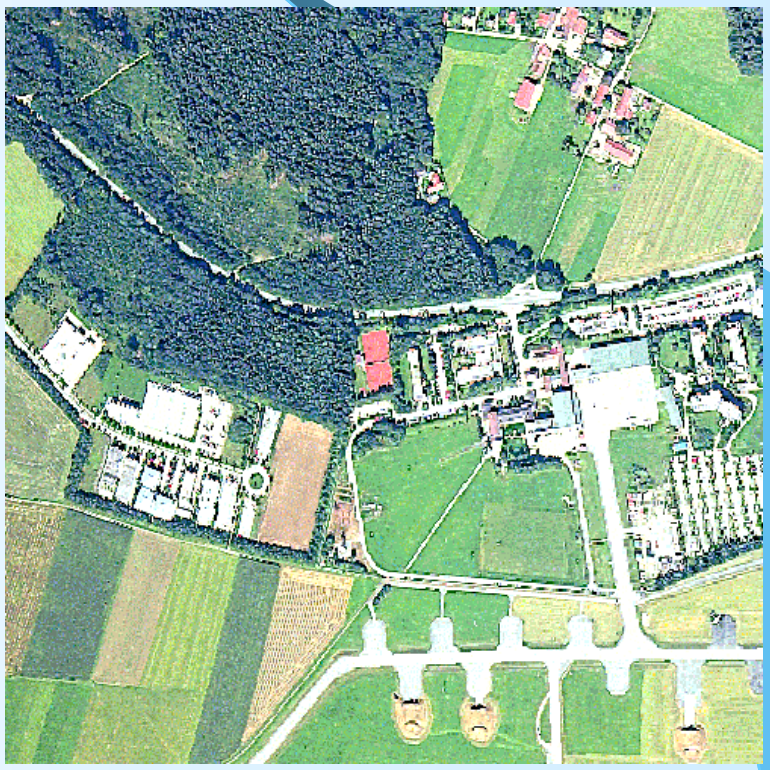
(color compositions)

POLSAR classification results

IDAN

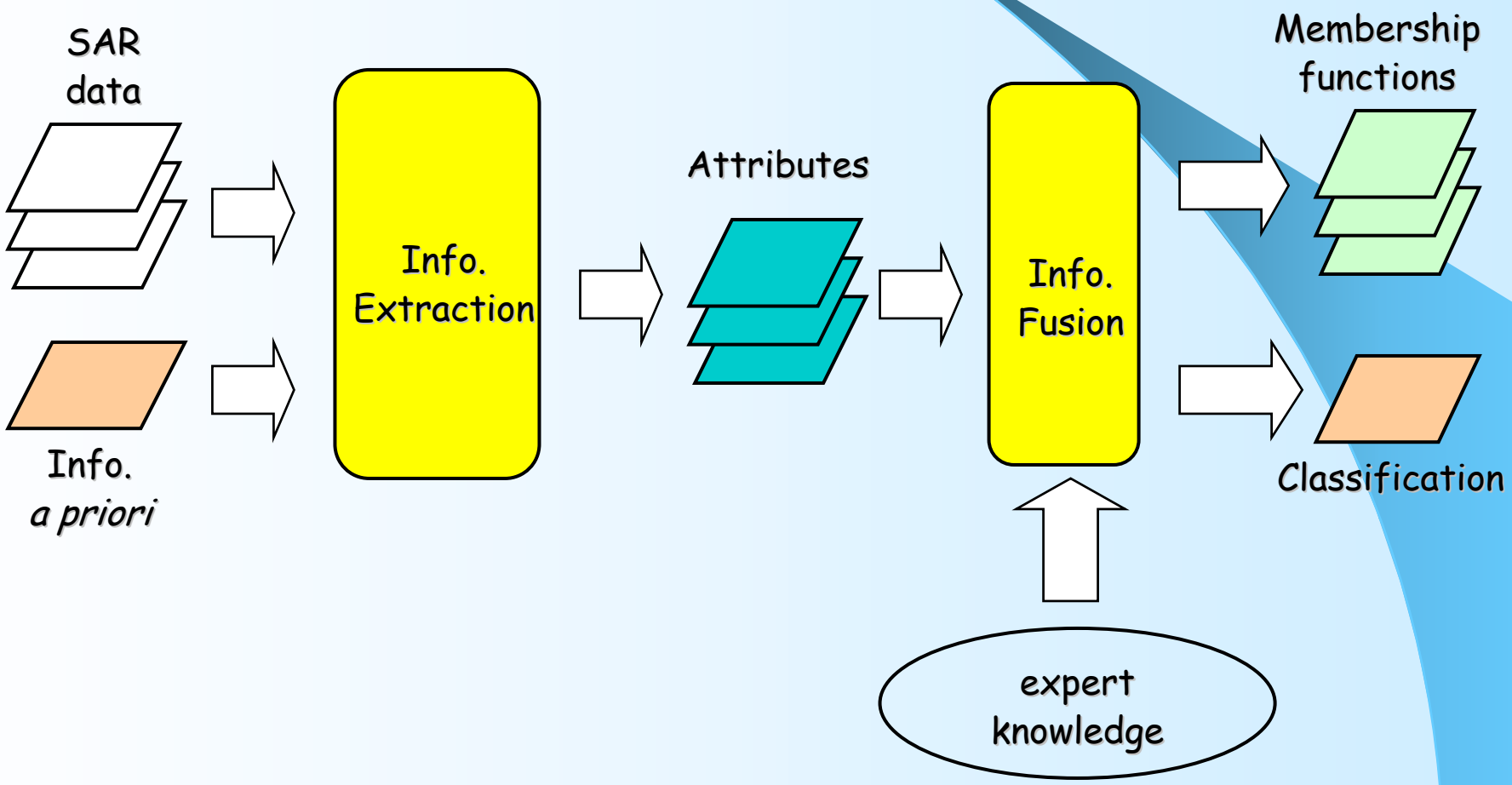


optical image

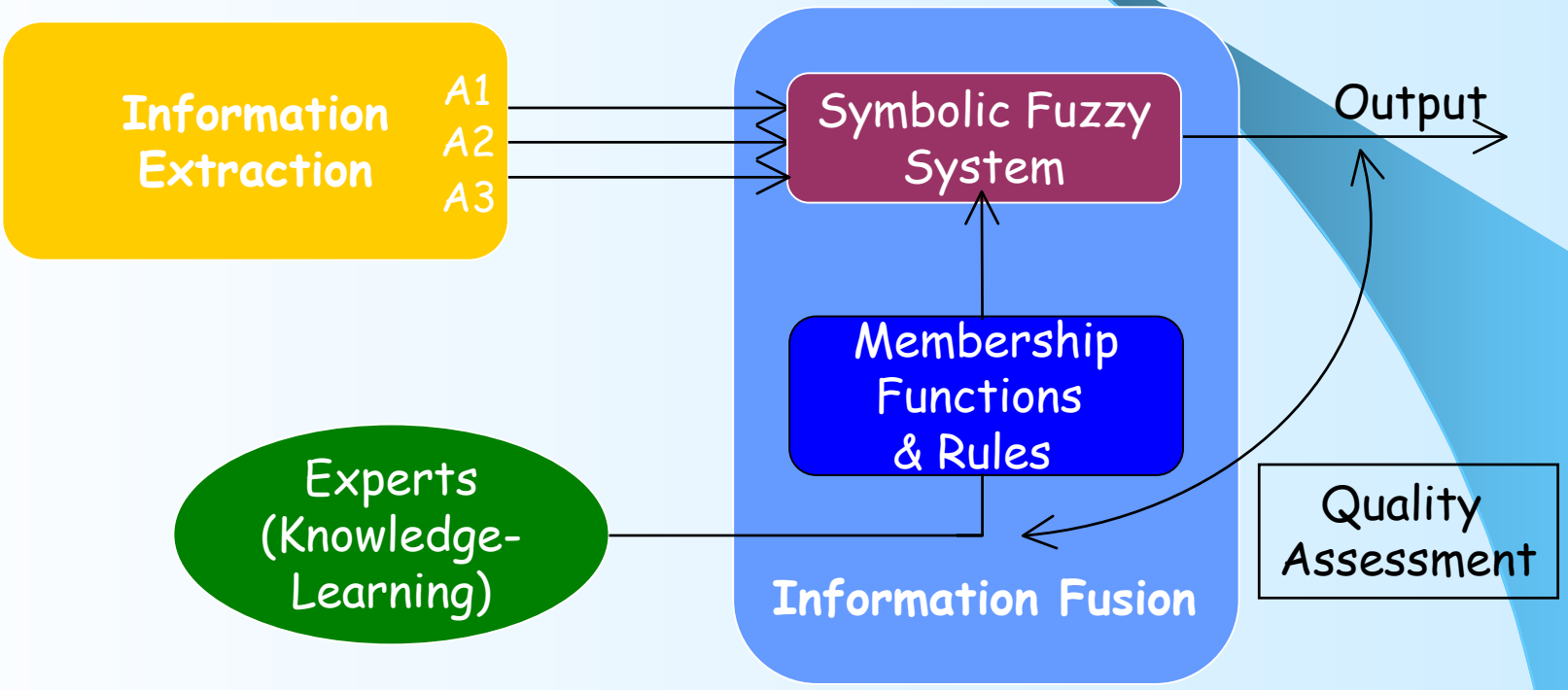


T_{11} Wishart classification results

Fusion « Feature level »

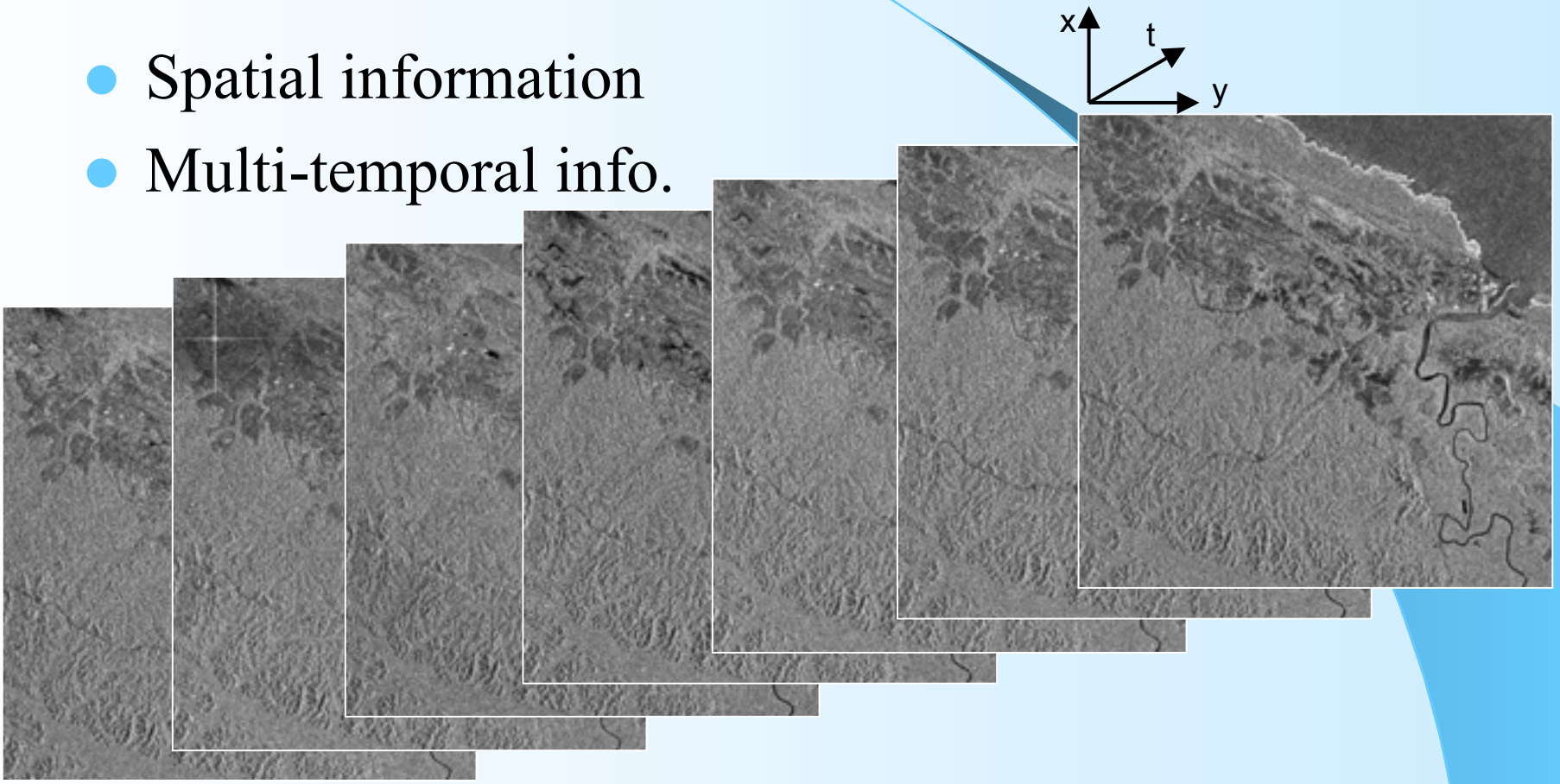


Interactive information fusion



Multi-temporal SAR Data

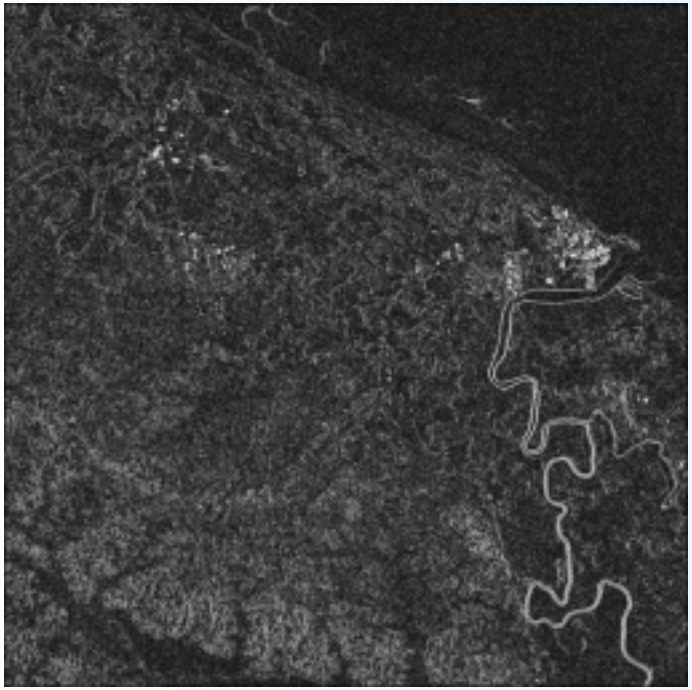
- Spatial information
- Multi-temporal info.

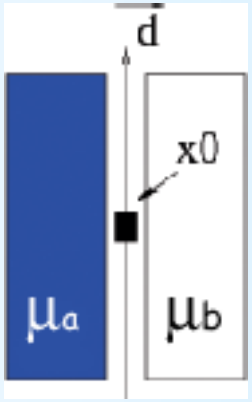


Simultaneous temporal & spatial information extraction

Information extraction

- Spatial edge attribute





• 1 image

$$\rho_n = 1 - \min\left(\frac{\mu_a}{\mu_b}, \frac{\mu_b}{\mu_a}\right)$$

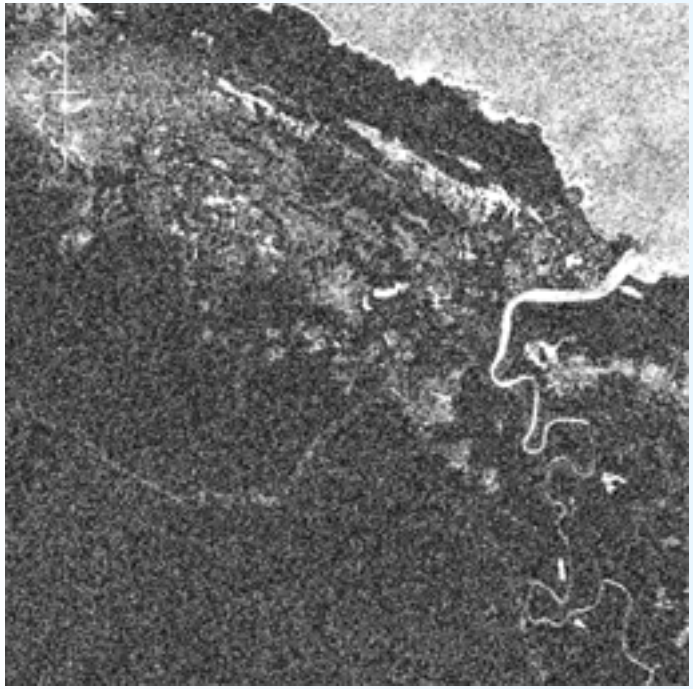
$$z_n = \rho_n \cdot e^{i\theta_n}$$

• N images

$$\rho = \left|\frac{1}{N}\sum_{n=1}^{N} z_n\right| \quad \text{and} \quad \theta = \arg\left(\sum_{n=1}^{N} z_n\right)$$

Information extraction

- Temporal change attribute



- 2 images

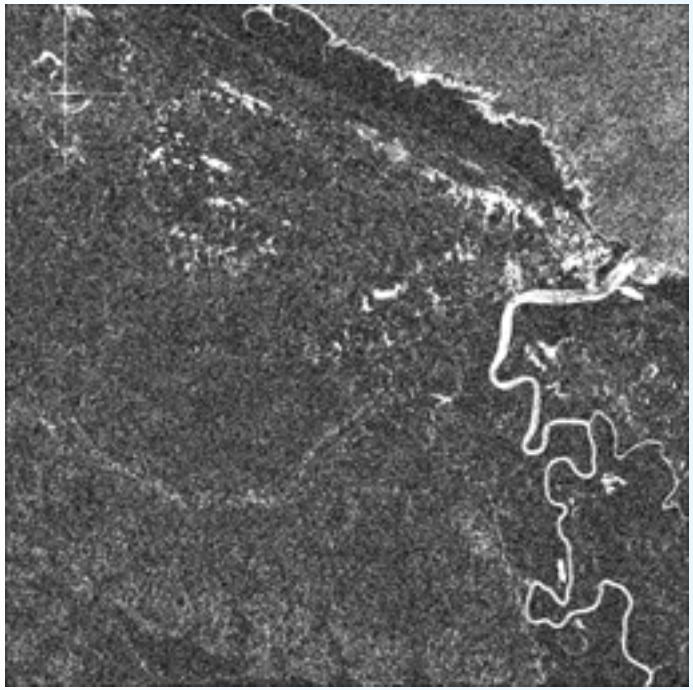
$$\nu(i,j) = \min\left(\frac{\mu_i}{\mu_j}, \frac{\mu_j}{\mu_i}\right)$$

- N images

$$\nu_{temp} = 1 - \min_{i \neq j}\left(\nu(i,j)\right)$$

Information extraction

- 3D-Texture attribute



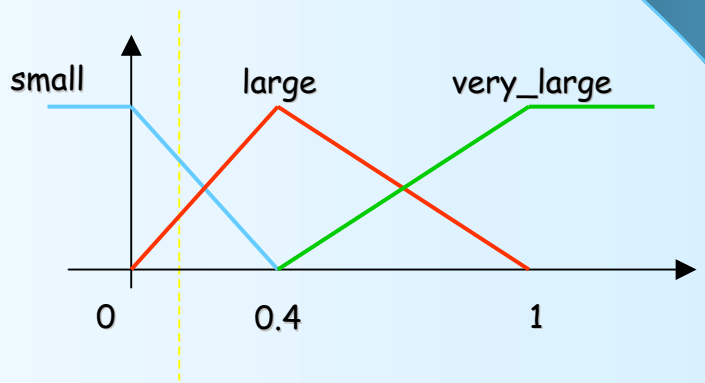
- Second order log-cumulants

$$\hat{\tilde{k}}_2 = \sum_{v} (\log I)^2 - \left(\sum_{v} \log I \right)^2$$

- Spatial-temporal neighborhood

Interactive information fusion

- Symbolic description of the attributes

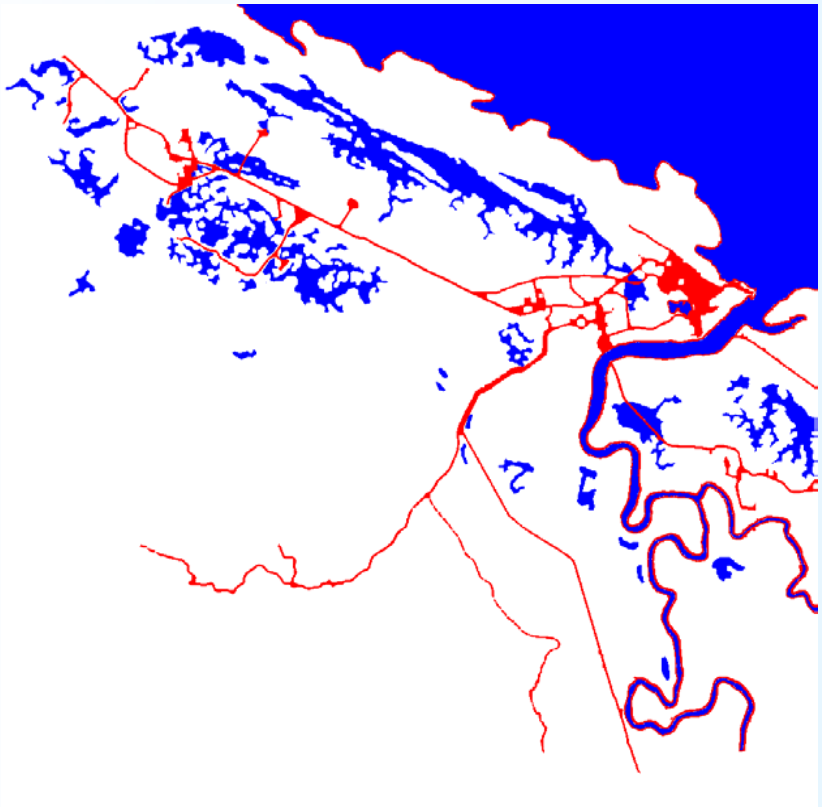


- Fuzzy rules

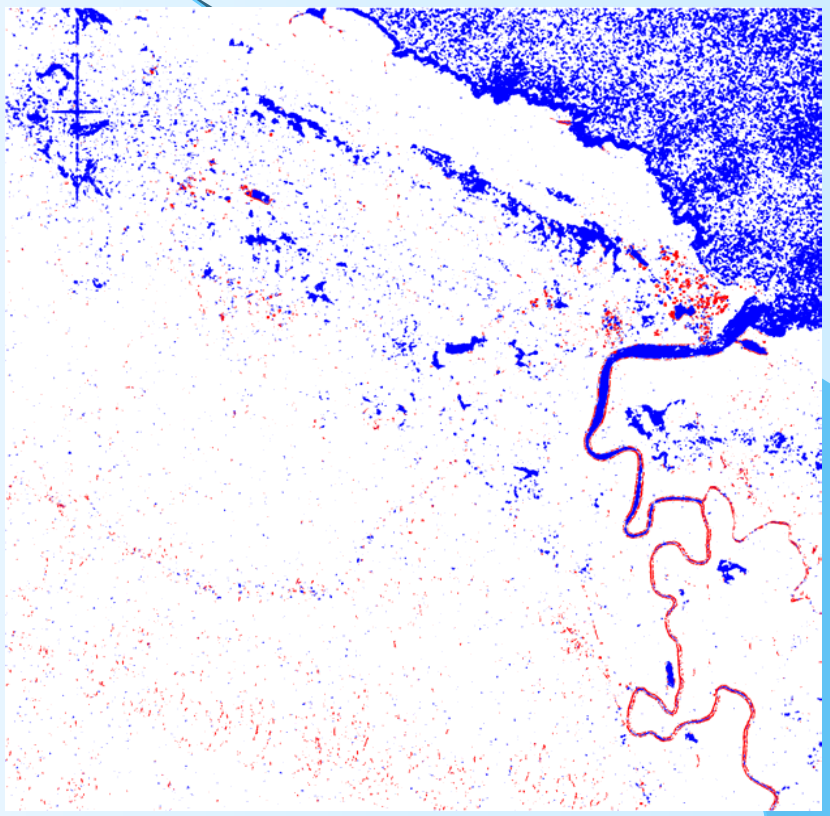
IF {A_1 is *very_large*} AND {A_2 is *large*}
THEN {the output belongs to the class *temporal_change*}.

- Aggregation by Zadeh composition rule

Multi-temp fusion results

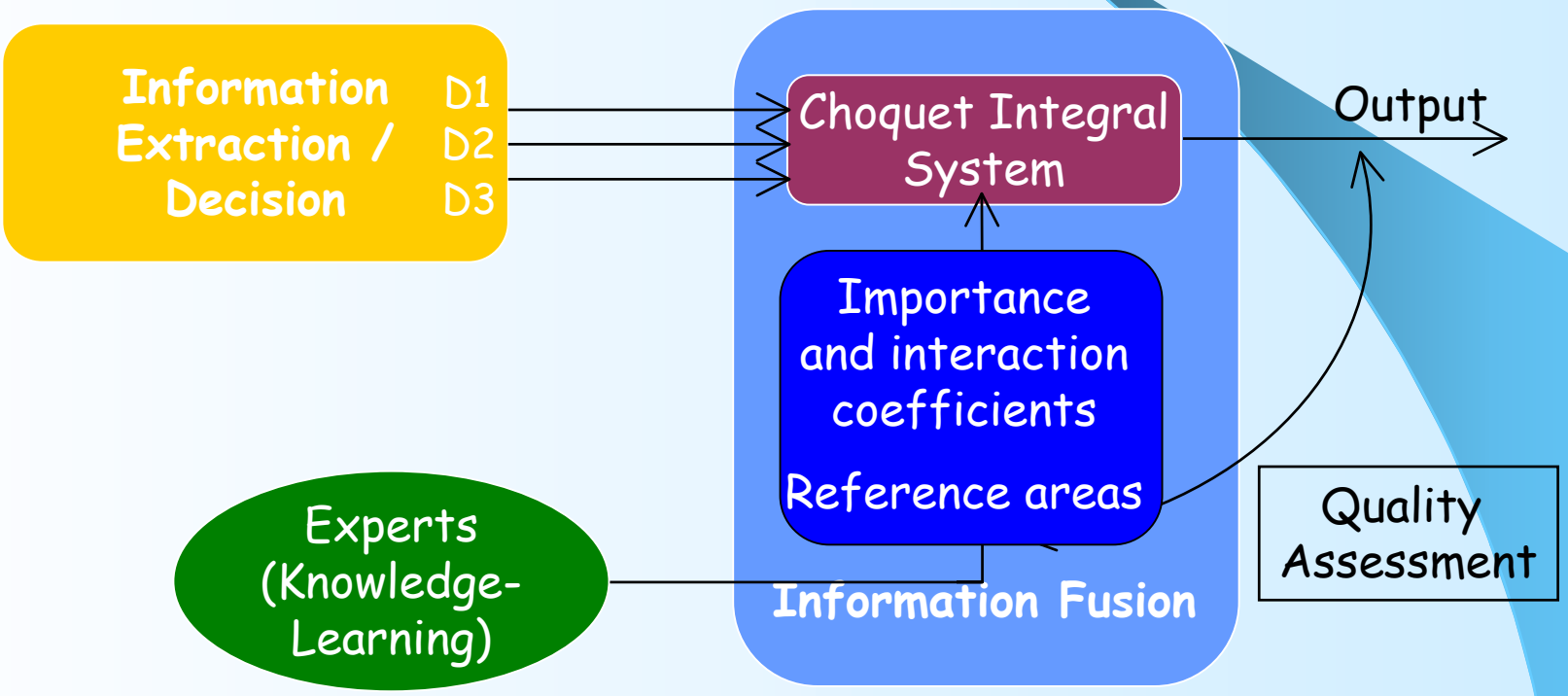


Ground truth



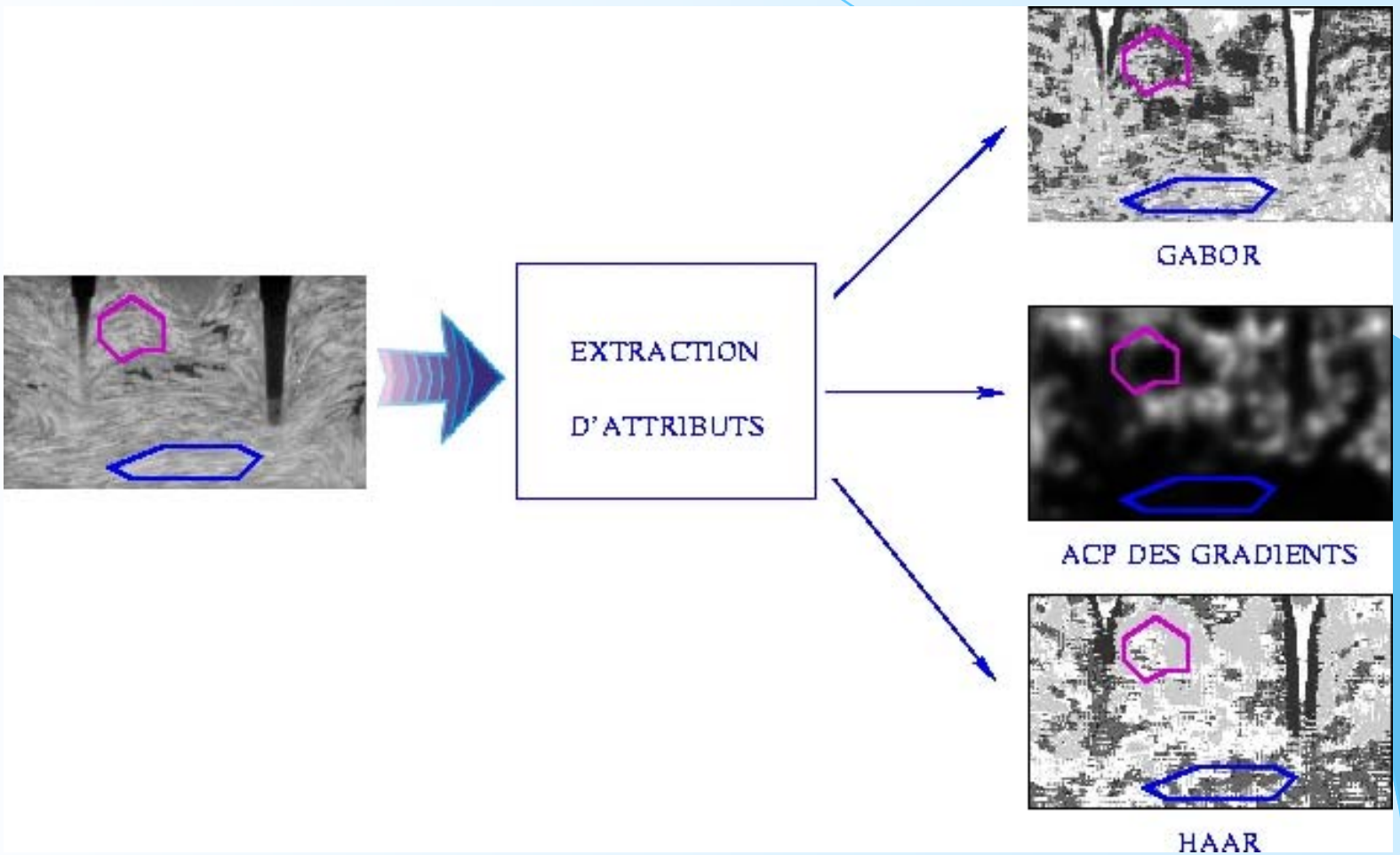
Fusion result

Feature/Decision level information fusion



Default detection in 3D tomographic data

Pixel →Features

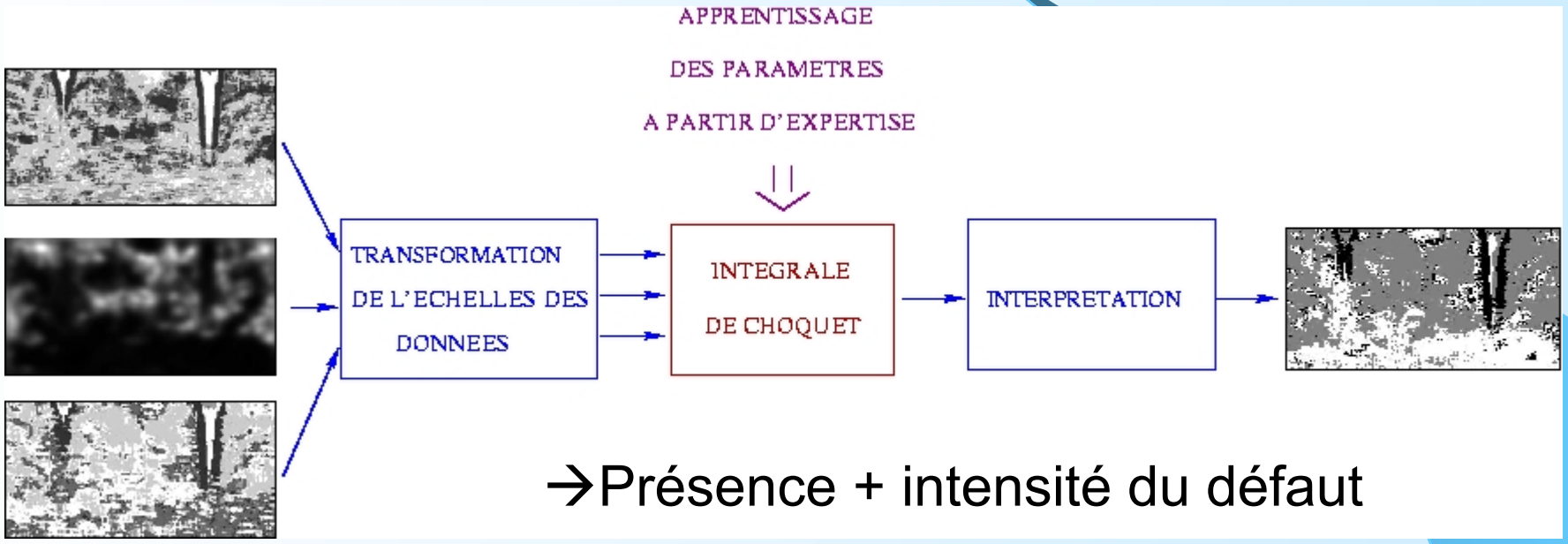


2-additive Choquet integral aggregation

$$C_u(x_1, x_2, \ldots, x_n) = \sum_{I_{ij} \phi 0} \min(x_i, x_j) I_{ij} + \sum_{I_{ij} \pi 0} \max(x_i, x_j) \left| I_{ij} \right| + \sum_{i=1}^{n} x_i \left(v_i - \frac{1}{2} \sum_{j \neq i} \left| I_{ij} \right| \right)$$

- v_i are the Shapley indices, representing the overall importance of each criterion c_i $(\sum_{i=1}^{n} v_i = 1)$
- I_{ij} represents the interactions between pairs of the criteria $\left(I_{ij} \in [-1,1] \right)$
  - positive value implies a positive synergy (complementarity) among criteria c_i, c_j
  - negative value implies a negative synergy (redundancy) between both criteria
  - null value implies that the criteria are independent

Features/Decisions →Decision



→Présence + intensité du défaut

→ Qualité globale de la pièce

→Action sur le process

Conclusions

- ***Fusion Tools available at the different levels***
  - Merging Optical, Radar and Prior Information
  - Integrating Expert Knowledge
  - Interactivity
- ***ORFEO HR Data analysis***
  - Pixel → Feature/Object → Decision
  - Application driven tools