

EQUIPE  
"Vision Par Calculateur André Bruel"

LIMA - IRIT - ENSEEIHT

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**STEREOVISION AXIALE:**  
CALIBRAGE, APPARIEMENT

et

RECONSTRUCTION  
TRIDIMENSIONNELLE.

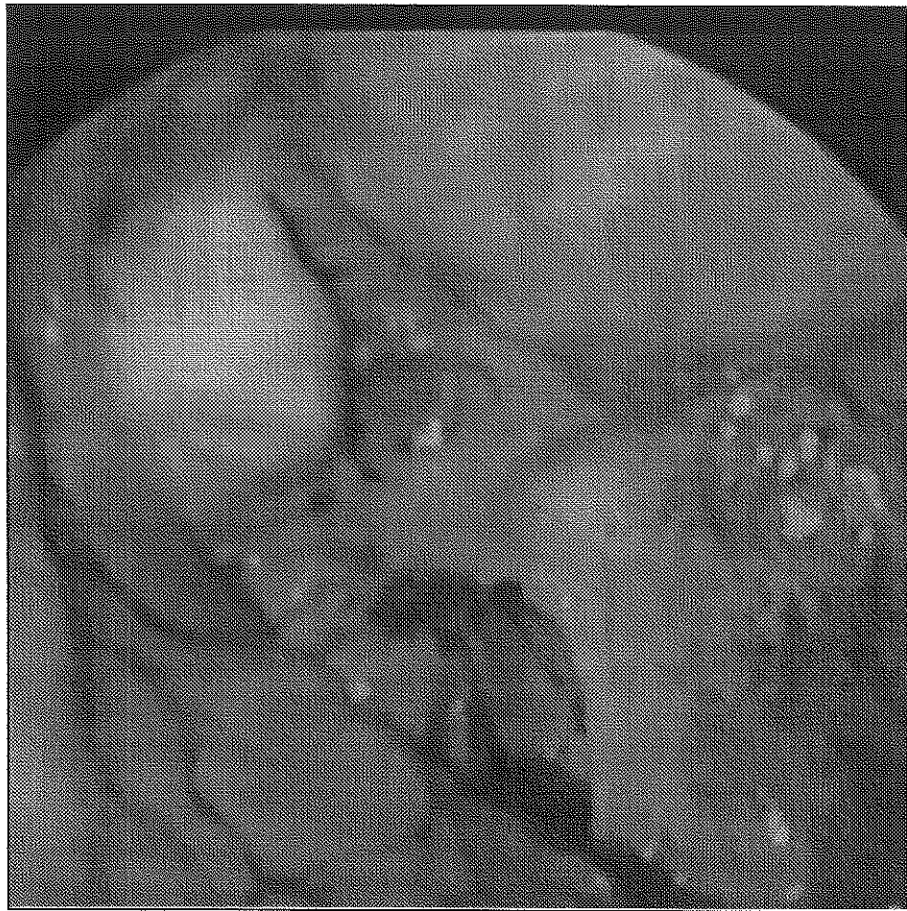
APPLICATION EN CÆLIOCHIRURGIE

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Vincent RODIN

LE 8 OCTOBRE 1993

# APPLICATION EN CŒLIOCHIRURGIE



PROBLEME:      FORME DES ORGANES



GESTE MEDICAL  
PLUS SUR ET PRECIS

CALCUL DU RELIEF }  
UNE SEULE CAMERA } ⇒

STEREOVISION  
AXIALE

# STEREOVISION AXIALE

## I- PRESENTATION

1. MODELE GEOMETRIQUE
2. EQUATIONS DE TRIANGULATION
3. ETUDE THEORIQUE DES ERREURS DE TRIANGULATION

## II- CALIBRAGE

1. IDEES CLEFS  $\Rightarrow$  Physiquement axial ?
2. CALIBRAGES INDEPENDANTS
3. RECTIFICATION

## III- PREMIERES EXPERIENCES

1. ETUDES PRATIQUES DES ERREURS
2. RECONSTRUCTION DE PLANS

## IV- APPARIEMENT

1. IDEES CLEFS  $\Rightarrow$  Profils d'intensité
2. FILTRE MEDIAN "SEUILLE"
3. MISE EN CORRESPONDANCE
4. RESULTATS

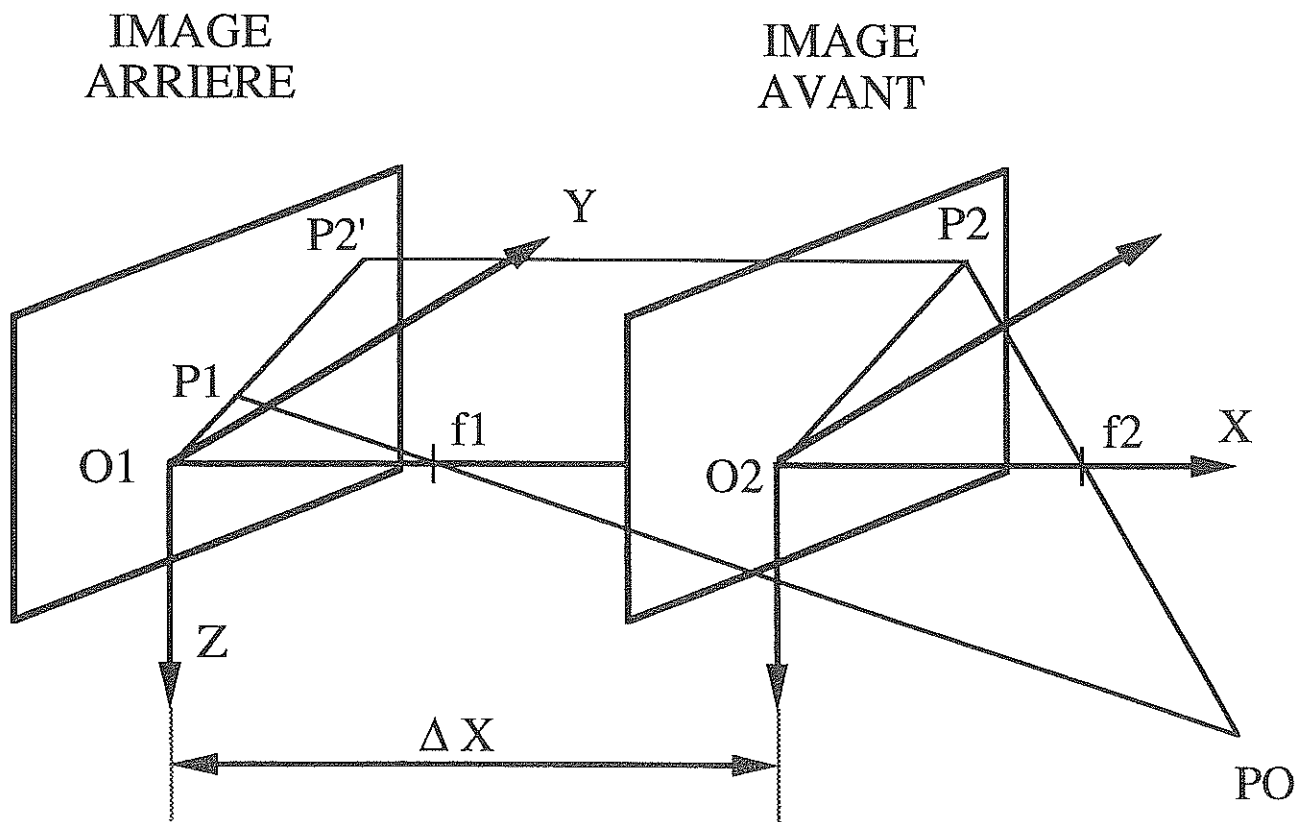
## V- RECONSTRUCTIONS 3D

OBJETS: POLYEDRIQUE et NATUREL

## VI- CONCLUSION - PERSPECTIVES

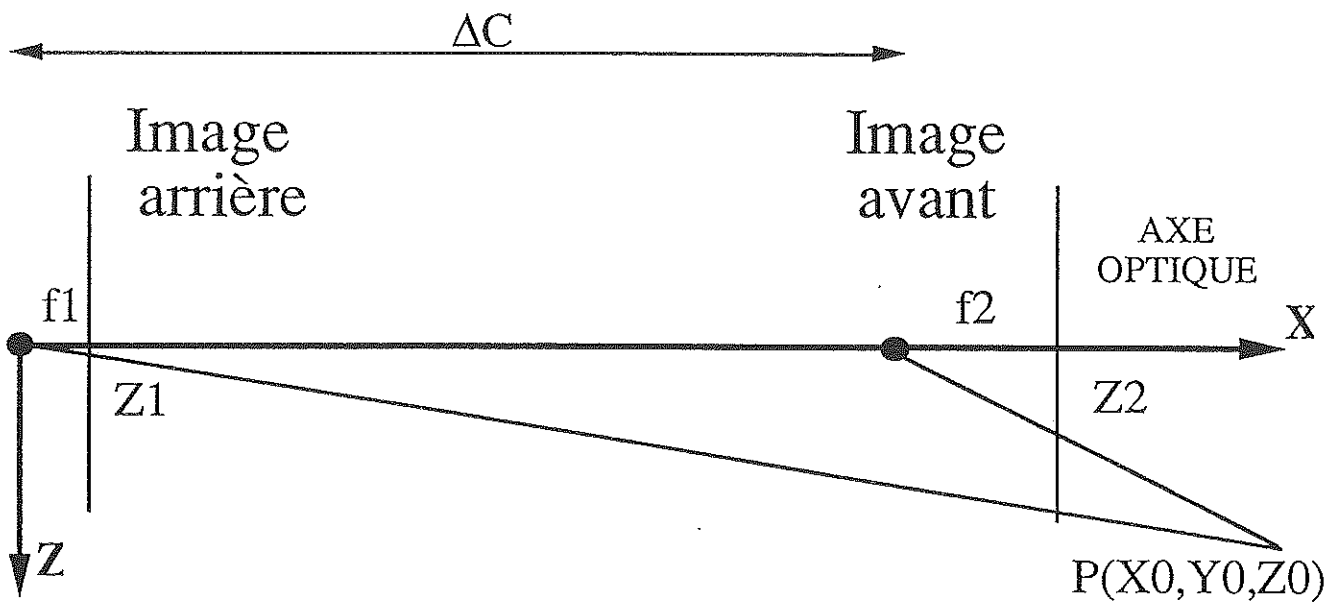
# I- PRESENTATION

## 1. MODELE GEOMETRIQUE



$$\left. \begin{array}{l} P_1(0, Y_1, Z_1) \\ P_2(\Delta X, Y_2, Z_2) \end{array} \right\} \Rightarrow P_0(X_0, Y_0, Z_0)$$

## 2. EQUATIONS DE TRIANGULATION

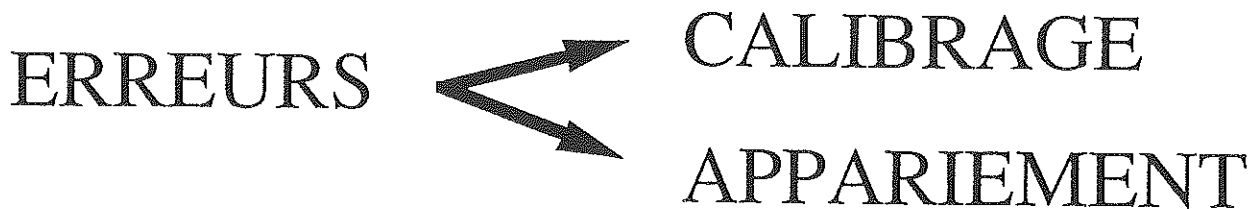


$$X_0 = \frac{Y_2 f_1 \Delta C}{Y_2 f_1 - Y_1 f_2} = \frac{Z_2 f_1 \Delta C}{Z_2 f_1 - Z_1 f_2}$$

$$Y_0 = \frac{Y_1 Y_2 \Delta C}{Y_2 f_1 - Y_1 f_2}$$

$$Z_0 = \frac{Z_1 Z_2 \Delta C}{Z_2 f_1 - Z_1 f_2}$$

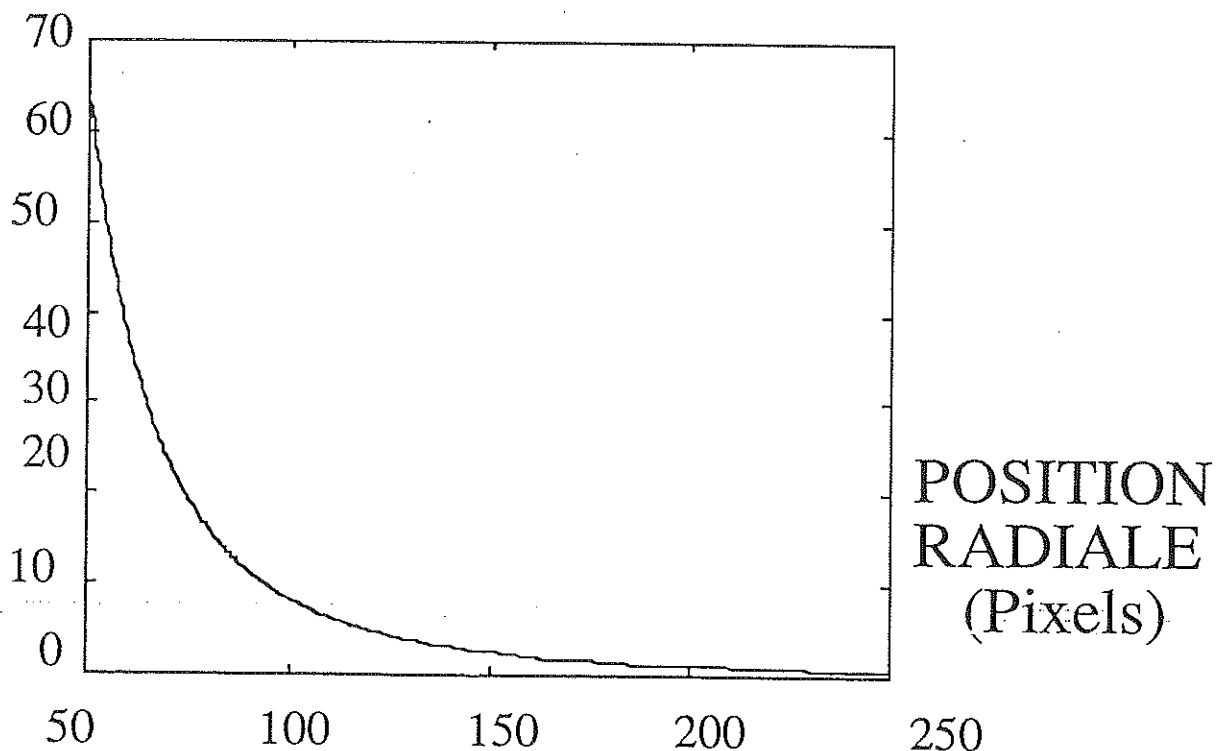
### 3. ETUDE THEORIQUE DES ERREURS DE TRIANGULATION



ERREUR D'APPARIEMENT: 0.02 PIXELS

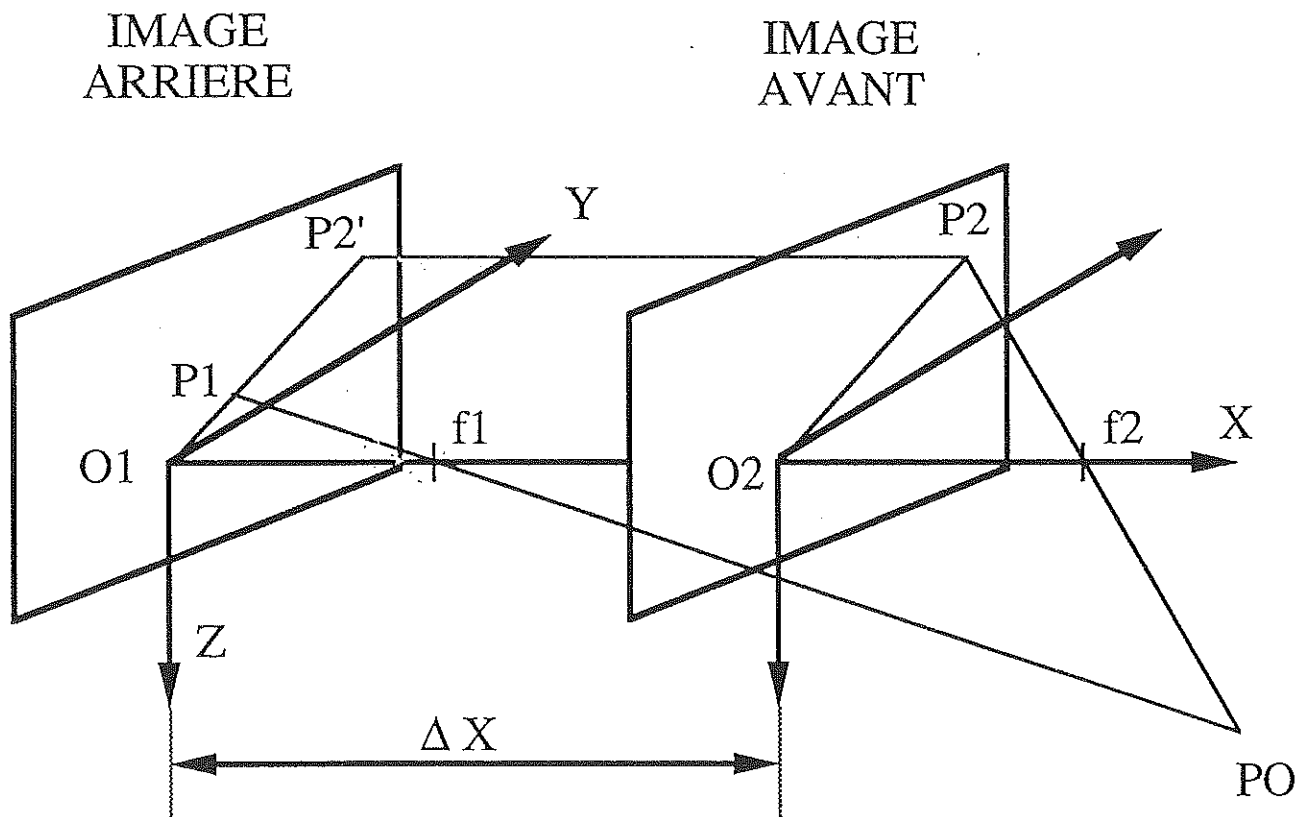
$$\text{Erreur} = \frac{\partial z f_2 (f_2 Z_0 + Z_2 \Delta C)^2}{Z_2 (f_1 \Delta C Z_2^2 - \partial z \Delta C f_2 Z_2 - \partial z f_2^2 Z_0)}$$

ERREUR SUR X<sub>0</sub> (mm)



## II - PROBLEME DU CALIBRAGE:

- CAMERA EN DEPLACEMENT SUR SON AXE (RAIL)
- CAMERA MUNIE D'UN ZOOM
- CAPTEUR SPECIALISE



1. IDEES CLEFS

UN SYSTEME PHYSIQUEMENT  
AXIAL EXISTE-T-IL ?

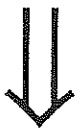
PROBLEMES MECANIKUES



NON



NE PAS SUPPOSER QU'UN  
SYSTEME EST AXIAL POUR LE  
CALIBRER



CALIBRAGES INDEPENDANTS



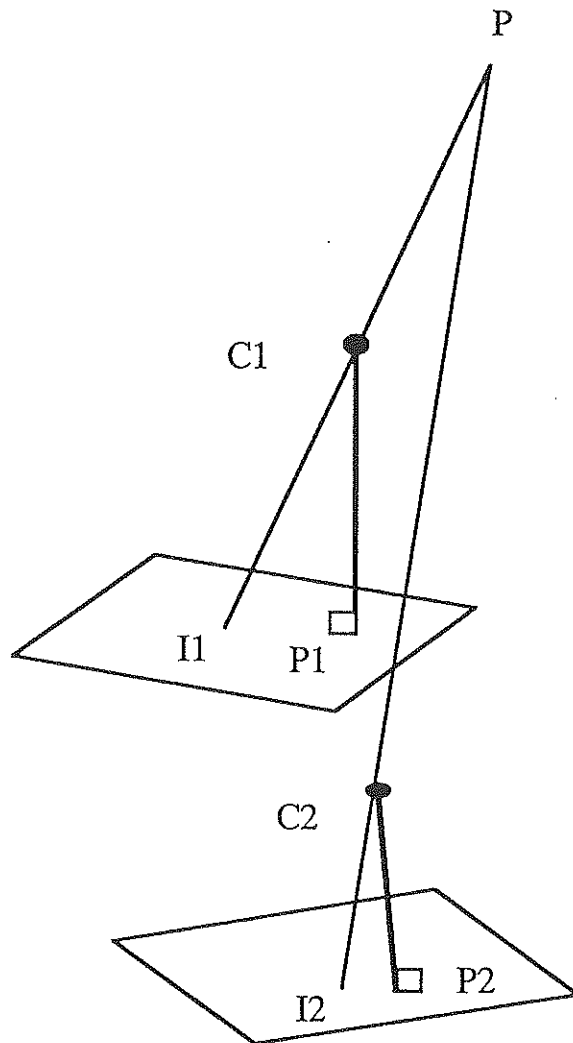
## 2. CALIBRAGES INDEPENDANTS

ESTIMATION  
DE PARAMETRES



POINTS 3D }  
POINTS 2D } ⇒

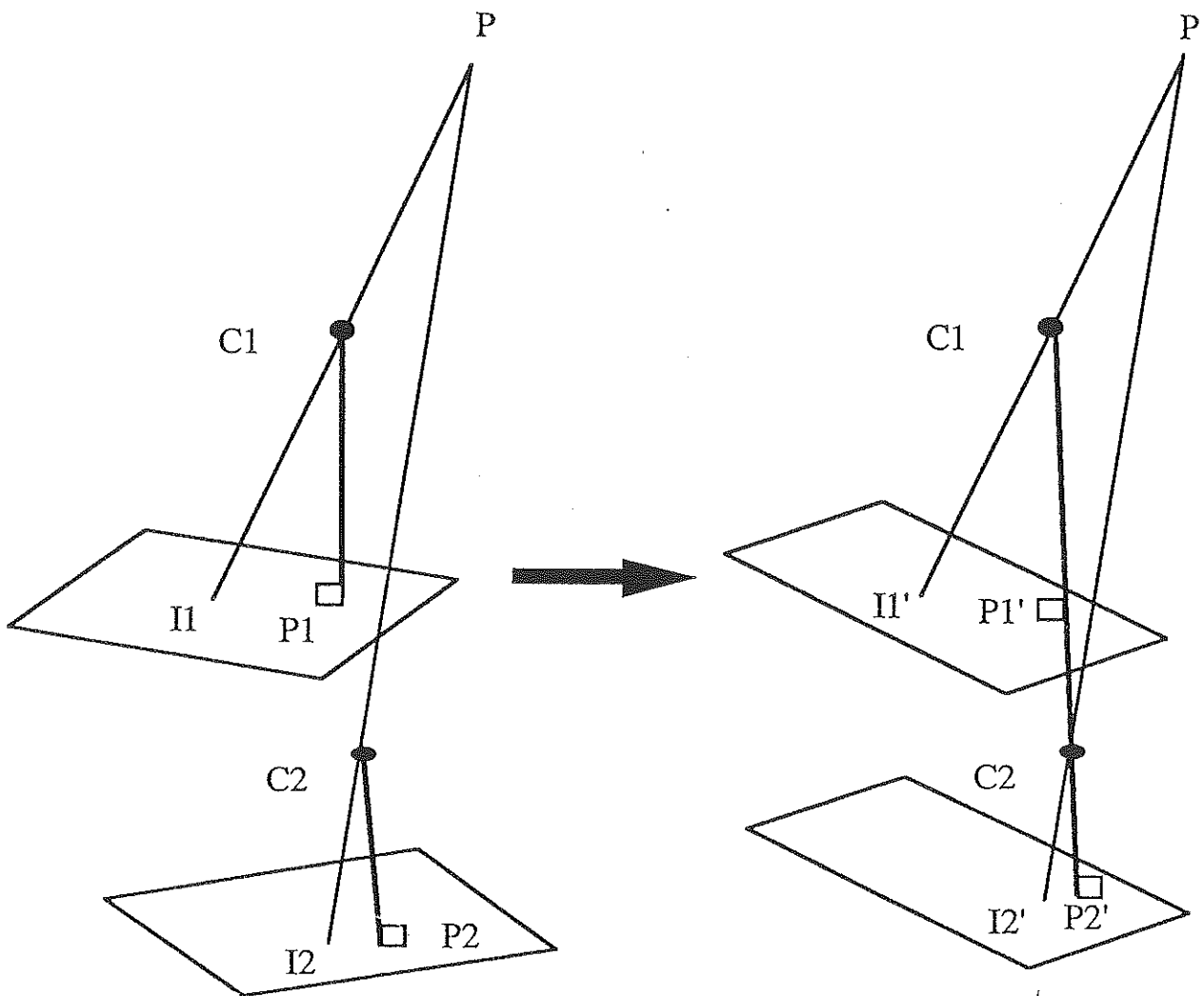
MODELE  
MATHEMATIQUE



### 3. RECTIFICATION :

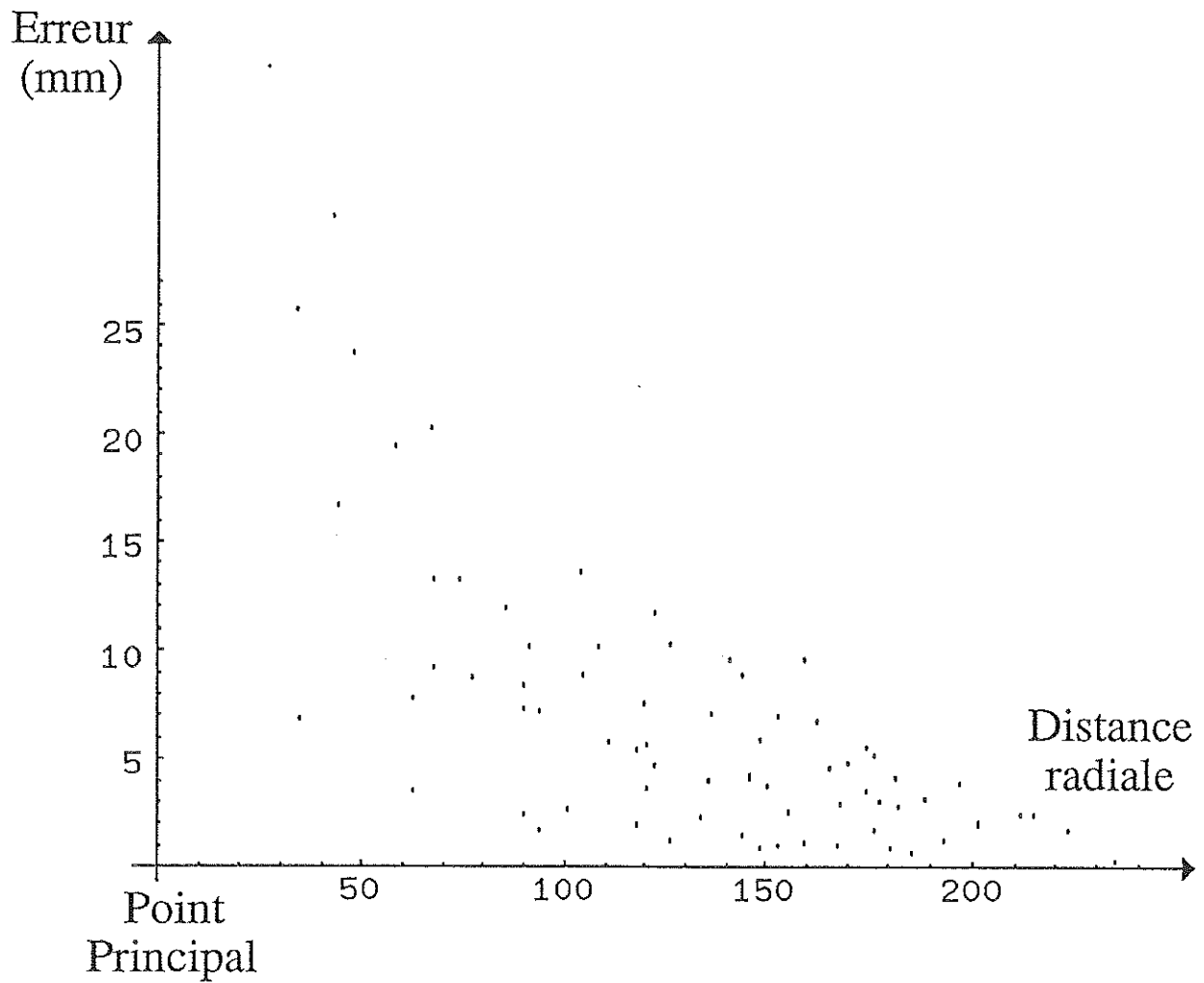
## ACCELERATION DU CALCUL DES DROITES EPIPOLAIRES

AXE OPTIQUE DU SYSTEME AXIAL  
⇒ DROITE PASSANT PAR LES  
CENTRES OPTIQUES



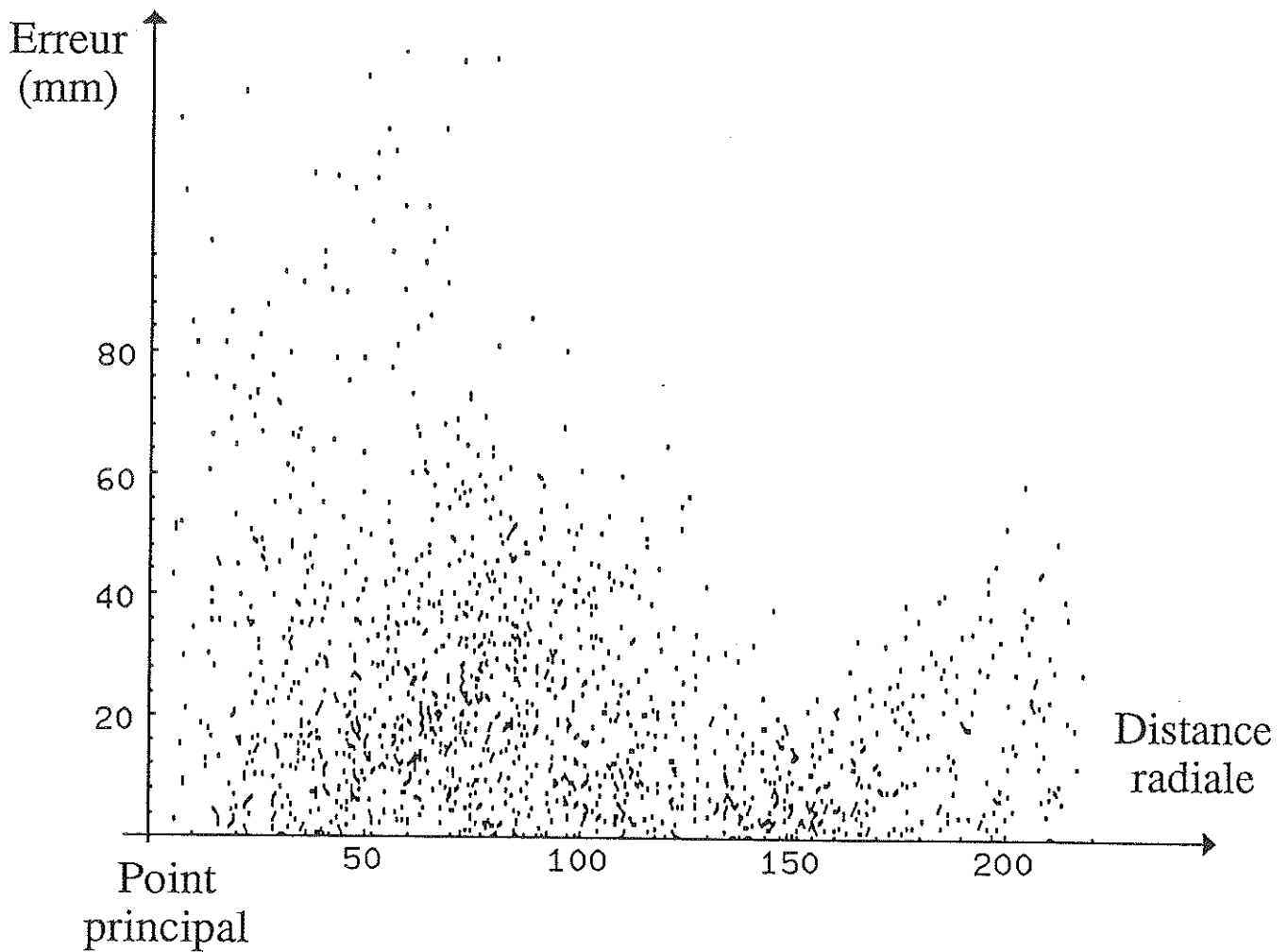
# 1. ETUDE PRATIQUE DES ERREURS:

## CAMERA EN MOUVEMENT

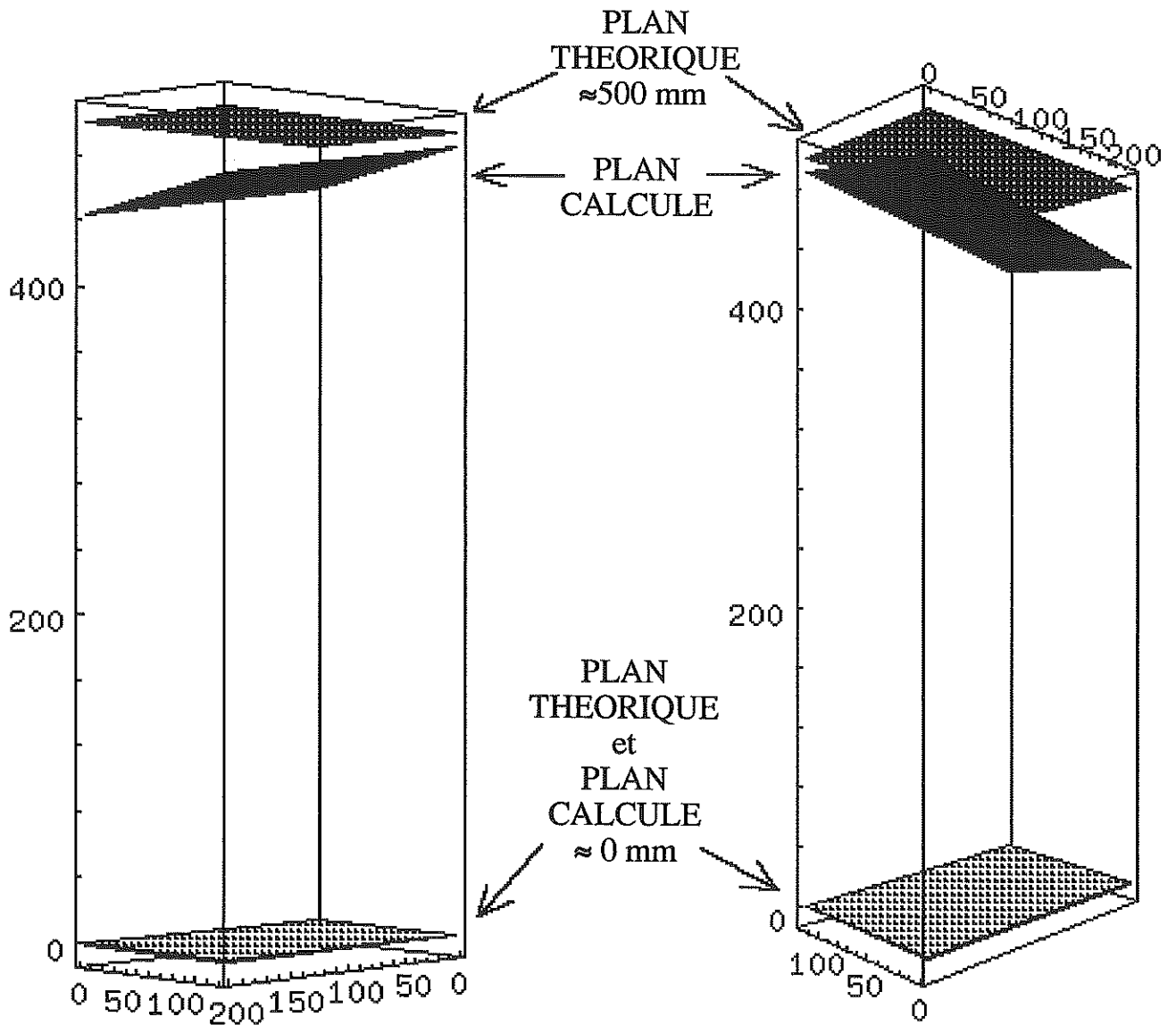
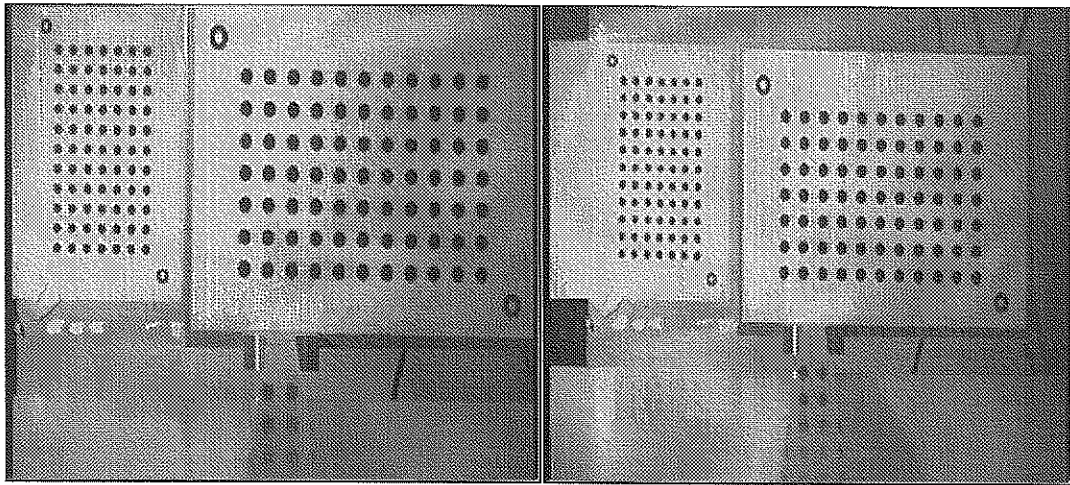


# 1. ETUDE PRATIQUE DES ERREURS:

## CAMERA MUNIE D'UN ZOOM

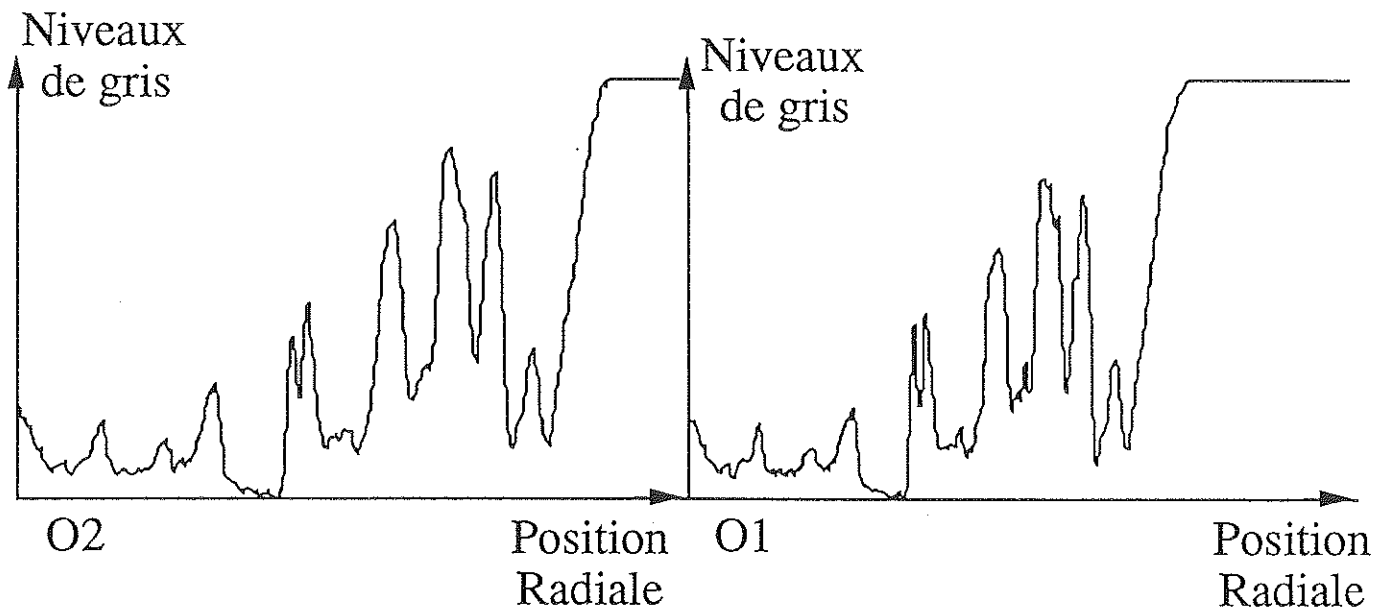


## 2. RECONSTRUCTION DE PLANS



# 1. IDEES CLEFS

## APPARIER DES POINTS CARACTERISTIQUES DES PROFILS D'INTENSITE LE LONG DES DROITES EPIPOLAIRES



PROFIL IMAGE AVANT

PROFIL IMAGE ARRIERE

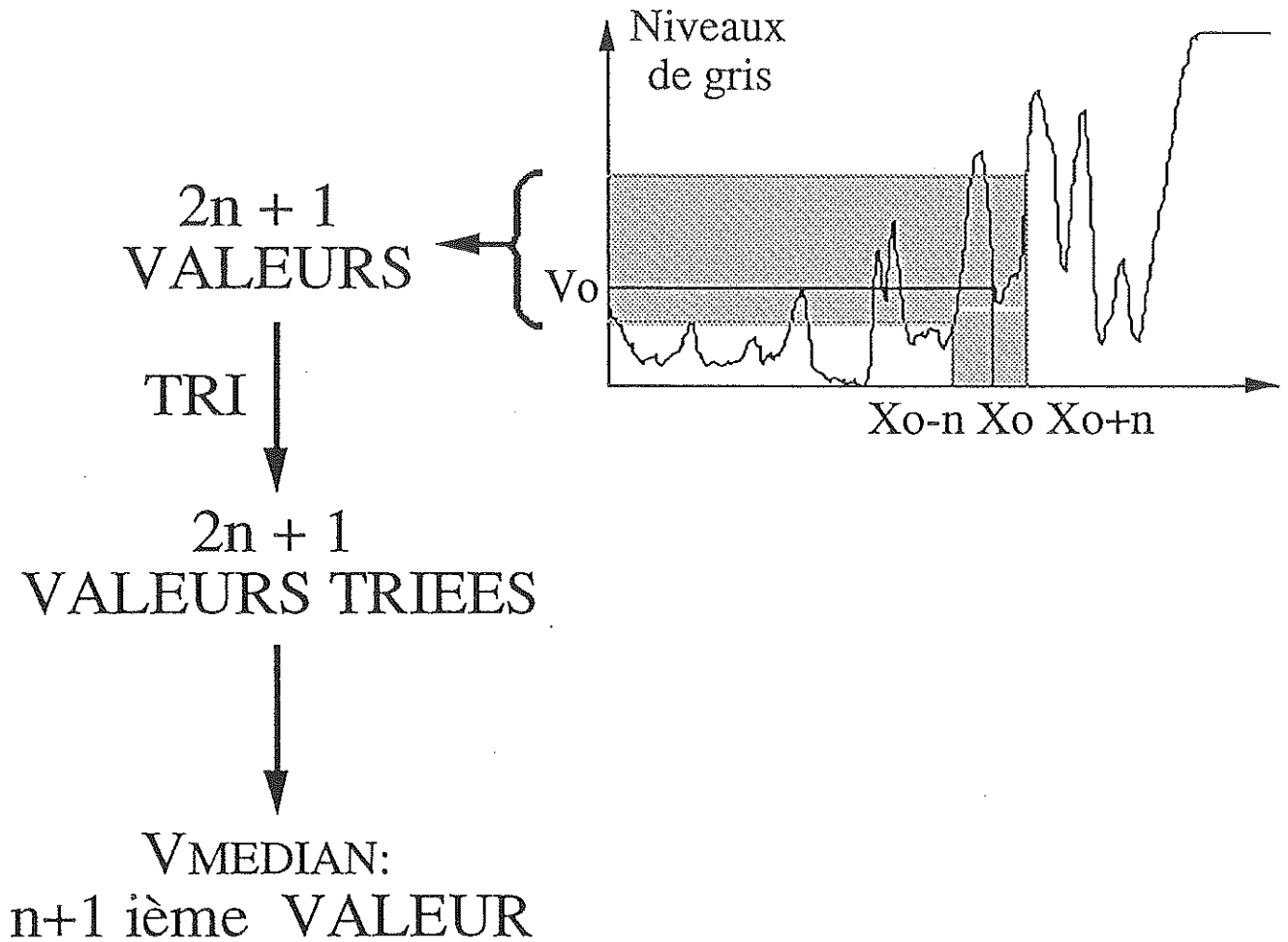


PROCESSUS DE FILTRAGE



PROCESSUS D'APPARIEMENT

## 2. FILTRE MEDIAN "SEUILLE"

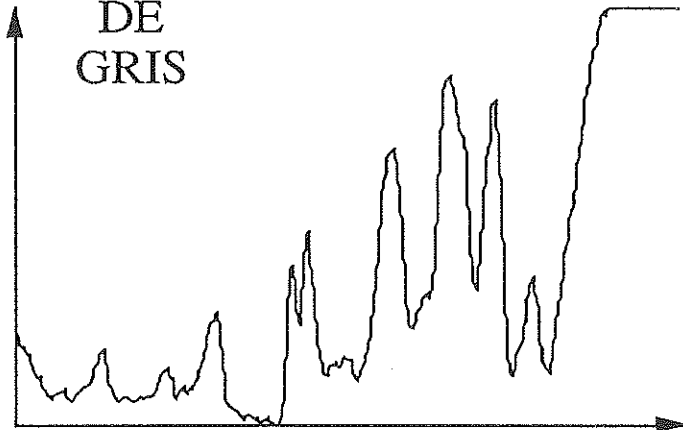


**$V_{ms}$  : VALEUR MEDIANE  
SEUILLEE**

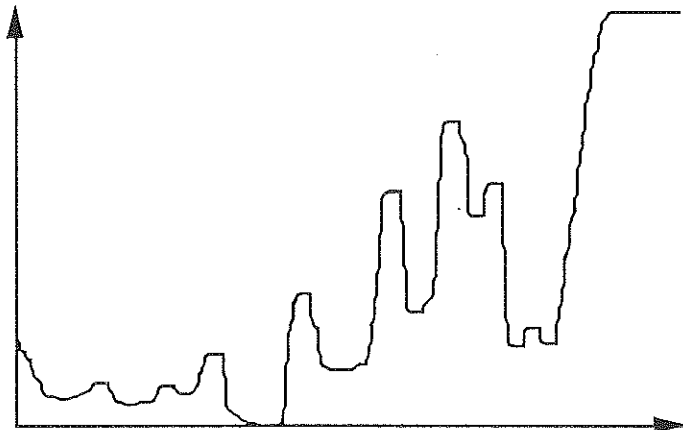
$$V_{ms} = \begin{cases} V_0 & \text{Si } |V_{\text{MEDIAN}} - V_0| \geq \text{Seuil} \\ V_{\text{MEDIAN}} & \text{Sinon} \end{cases}$$

## 2. FILTRE MEDIAN "SEUILLE"

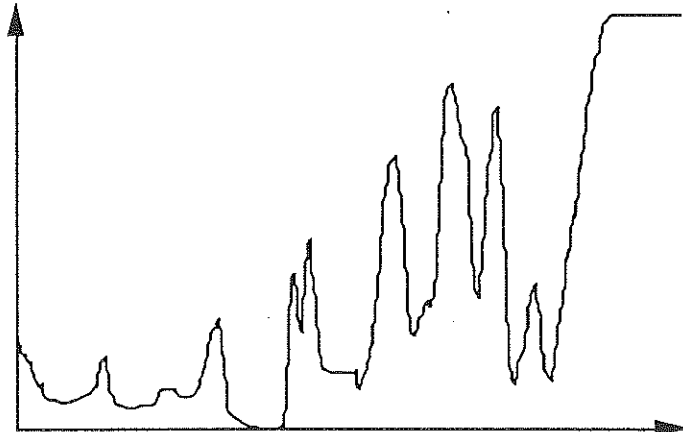
NIVEAUX  
DE  
GRIS



PROFIL  
ORIGINAL



APRES  
FILTRE MEDIAN

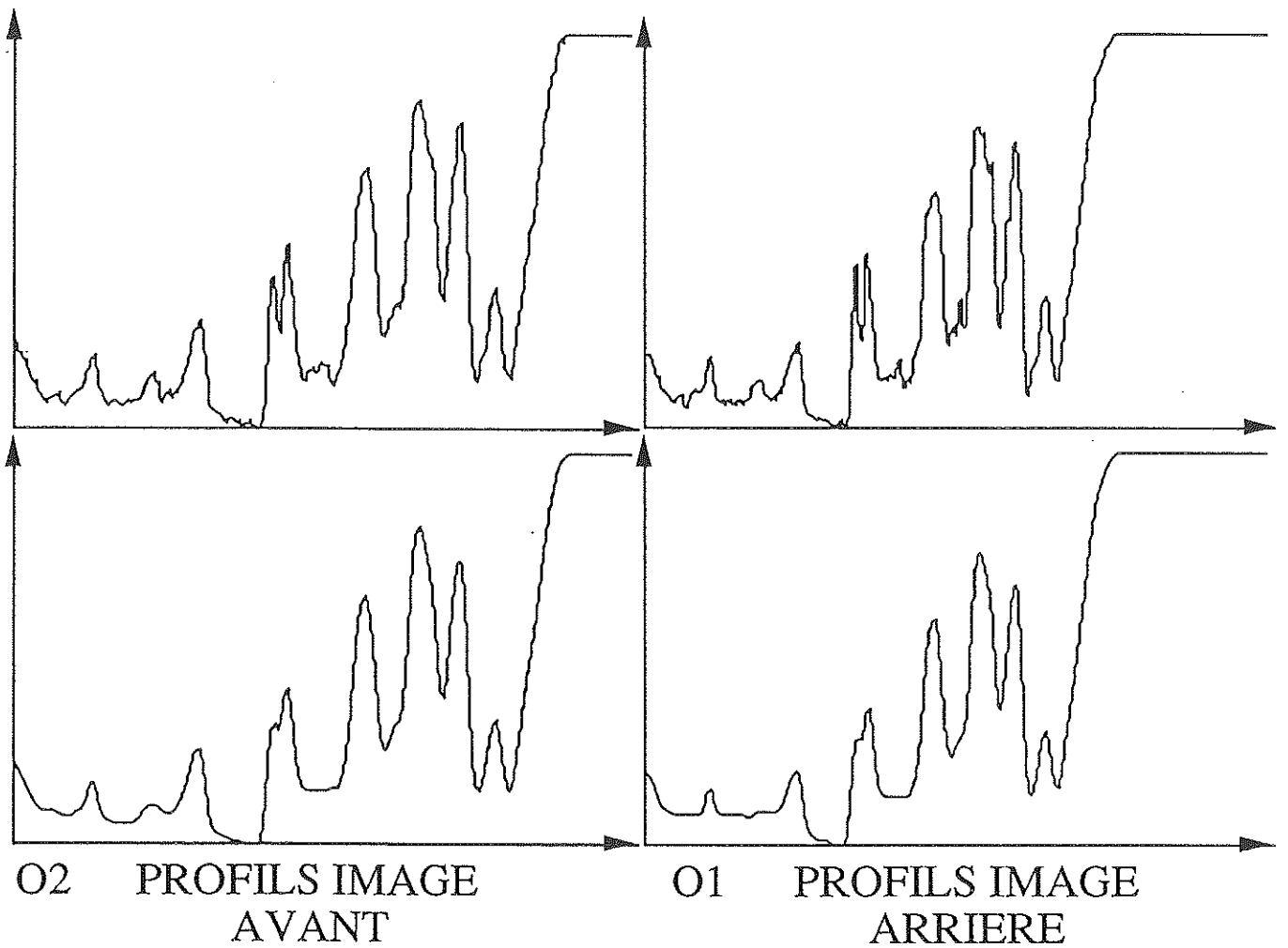


APRES  
FILTRE MEDIAN  
SEUILLE

**GARDE LES PICS ETROITS ET  
SIGNIFICATIFS**



### 3. MISE EN CORRESPONDANCE



APPARIEMENT

POINTS DE FORT GRADIENT

MAXIMA  
et  
MINIMA LOCAUX

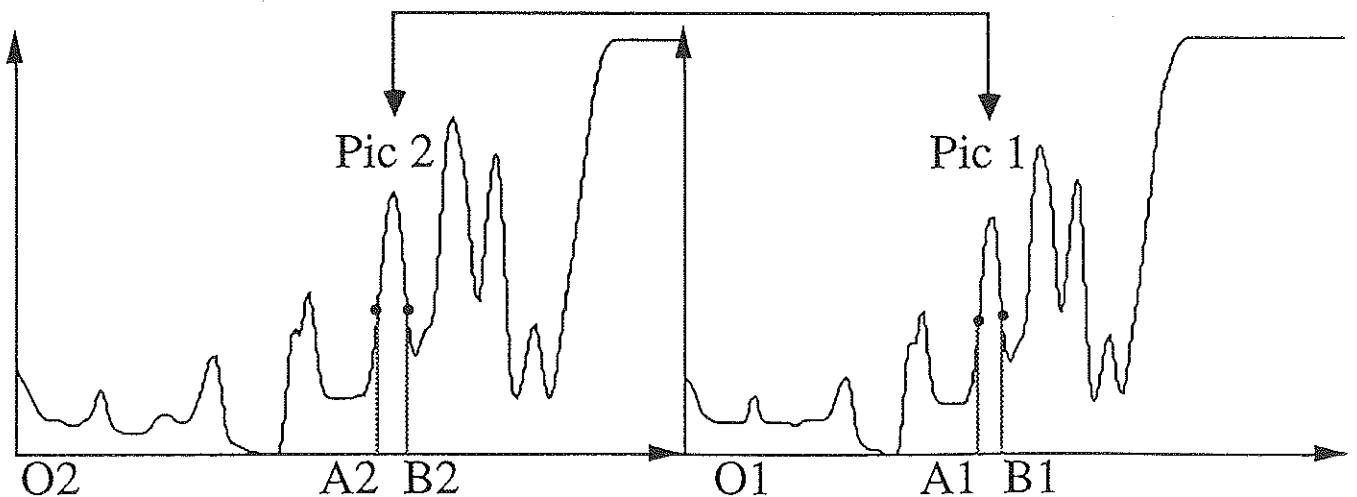
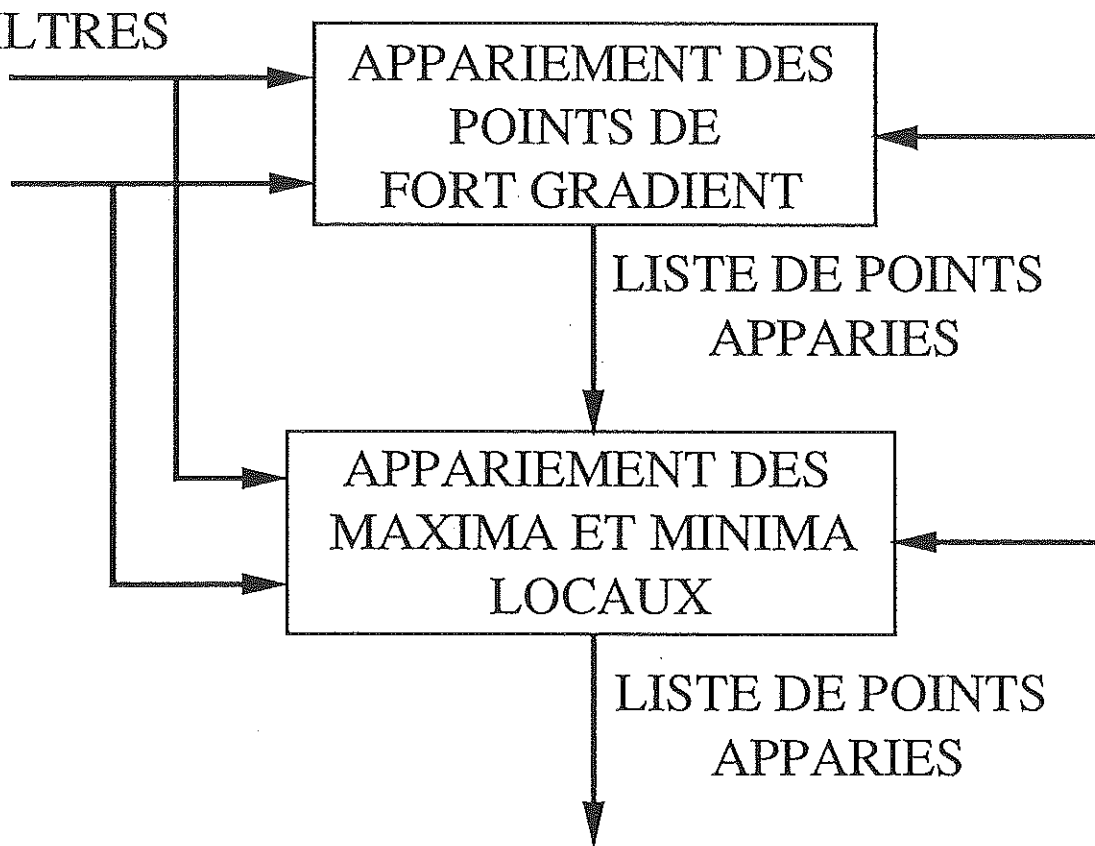
IV- APPARIEMENT

# 3. MISE EN CORRESPONDANCE

CONTRAINTES  
GEOMETRIQUES  
et  
RADIOMETRIQUES

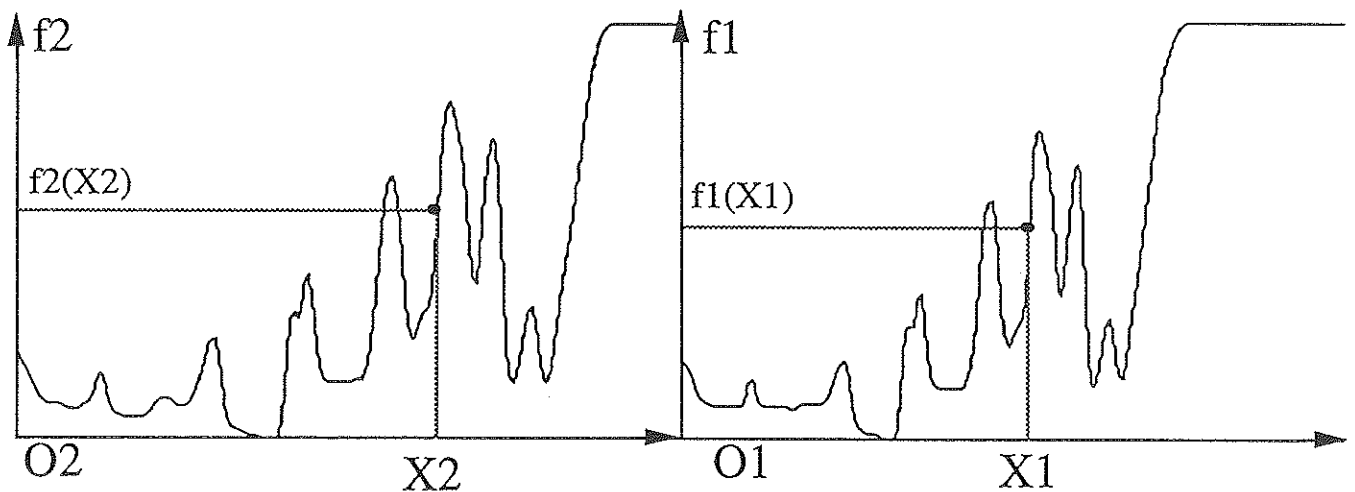
PROFILS  
FILTRES

RADIOMETRIQUES



## 3. MISE EN CORRESPONDANCE

## a- POINTS DE FORT GRADIENT:



Contraintes géométriques:

$$X2 \geq X1$$

Contraintes radiométriques:

$$f1(X1) \approx f2(X2)$$

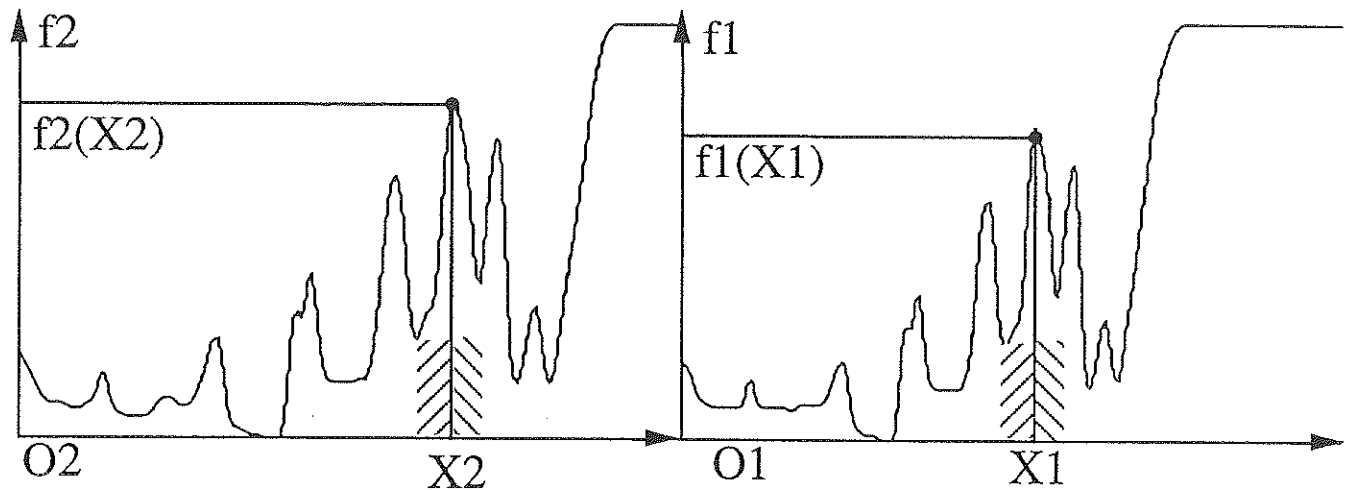
$$\frac{\partial f2(X2)}{\partial x} \approx \frac{\partial f1(X1)}{\partial x}$$

Minimisation:

$$\left| f2(X2) - f1(X1) \right| + \left| \frac{\partial f2(X2)}{\partial x} - \frac{\partial f1(X1)}{\partial x} \right|$$

## 3. MISE EN CORRESPONDANCE

## b- PICS ET VALLEES:



Contraintes géométriques:

$$X_2 \geq X_1$$

Contraintes radiométriques:

$$f_1(X_1) \approx f_2(X_2),$$

$$\text{Moyenne} (\uparrow_1) \approx \text{Moyenne} (\uparrow_2),$$

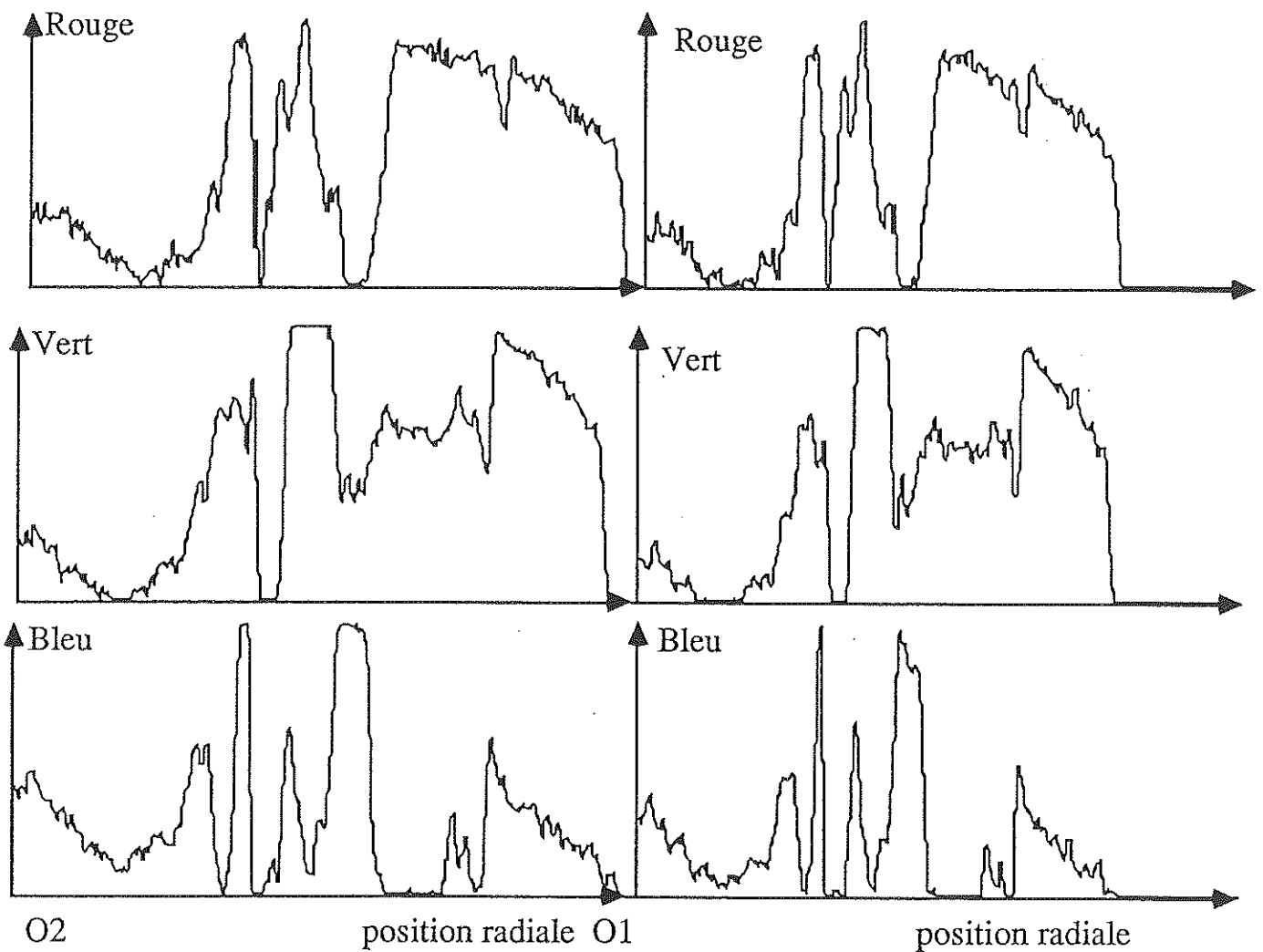
$$\text{Moyenne} (\downarrow_1) \approx \text{Moyenne} (\downarrow_2)$$

Minimisation:

$$\begin{aligned} & |f_2(X_2) - f_1(X_1)| + \\ & | \text{Moyenne} (\uparrow_1) - \text{Moyenne} (\uparrow_2) | + \\ & | \text{Moyenne} (\downarrow_1) - \text{Moyenne} (\downarrow_2) | \end{aligned}$$

### 3. MISE EN CORRESPONDANCE

APPARIEMENT DANS LES  
COMPOSANTES DE L'IMAGE:  
R, V, B, ...



### 3. MISE EN CORRESPONDANCE

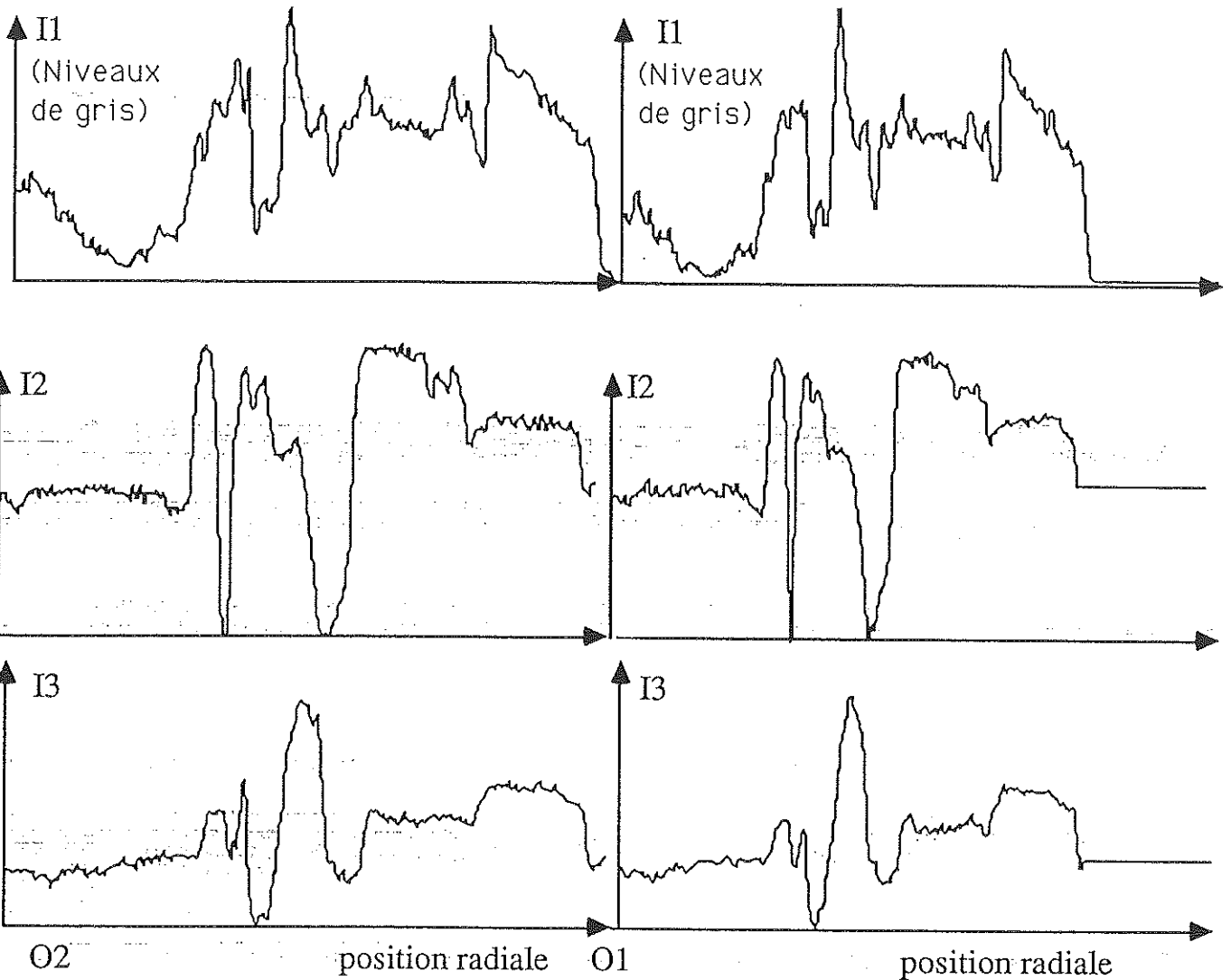
#### CHOIX DU SYSTEME DE REPRESENTATION DE LA COULEUR

$$I1 = R+V+B / 3$$

$$I2 = R - V / 2$$

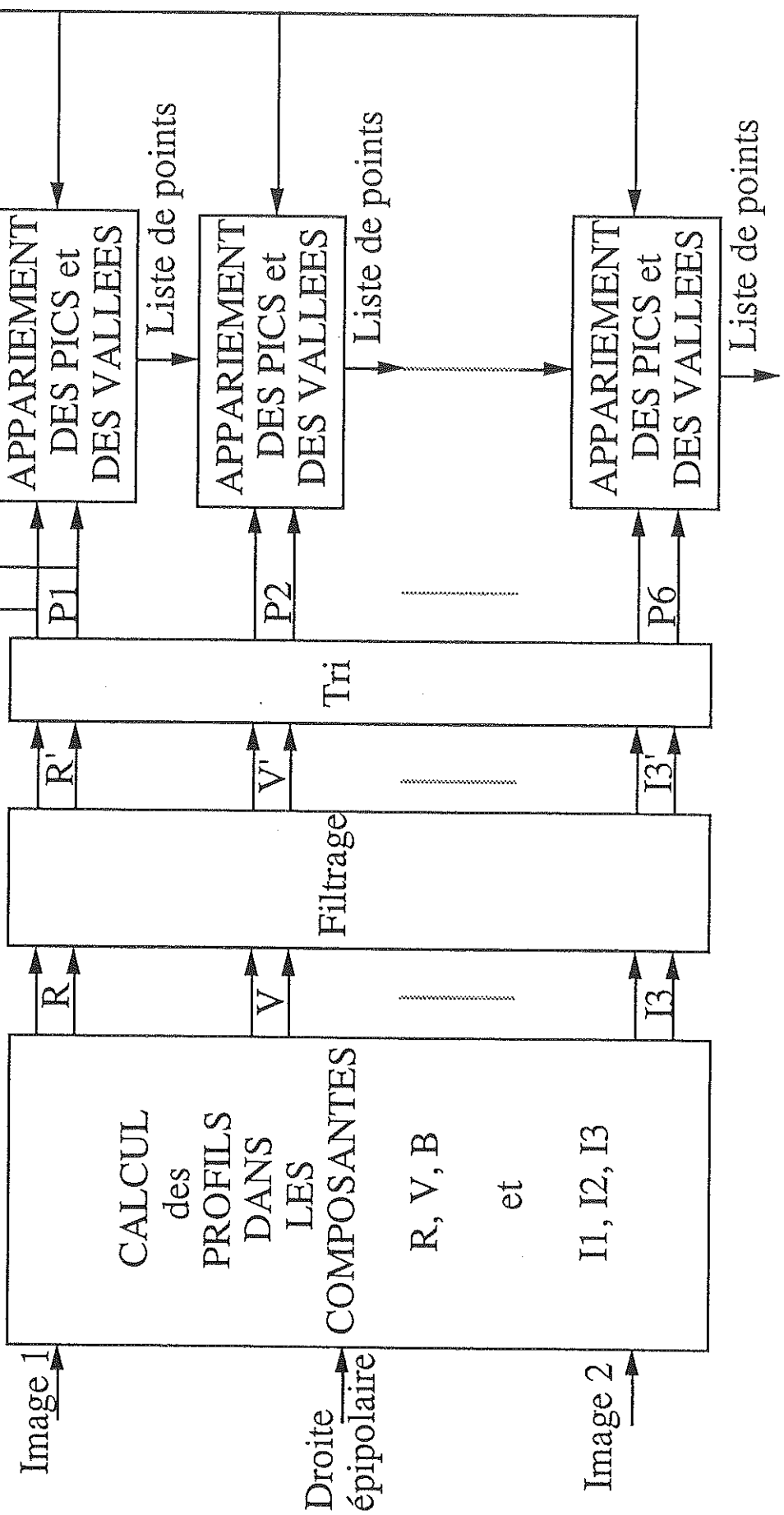
$$I3 = 2V - R - B / 4$$

DEFINI PAR Y.OHTA

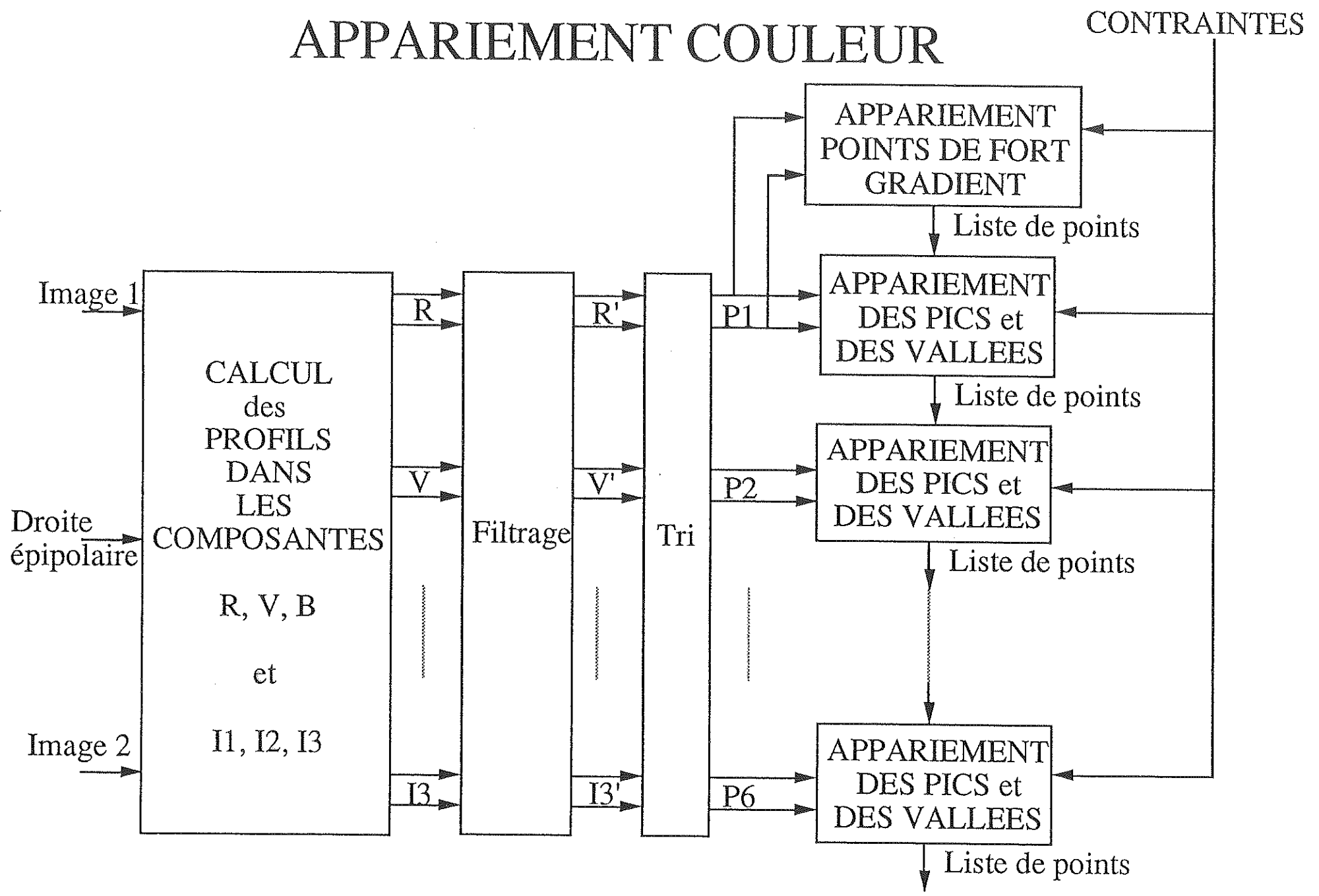


# APPARIEMENT COULEUR

CONTRAINTES

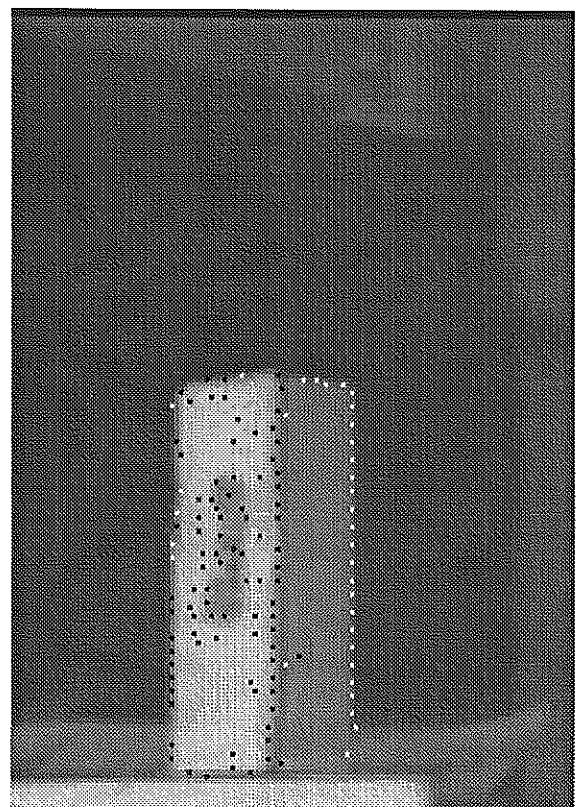
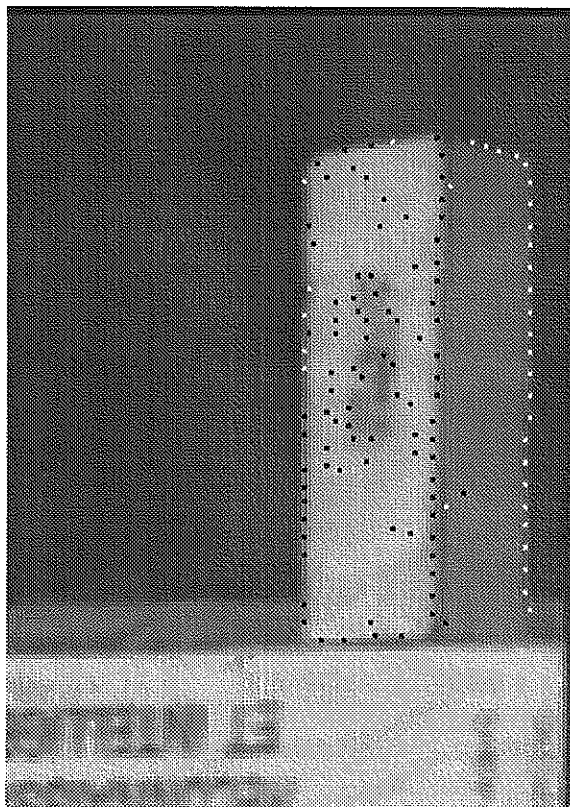
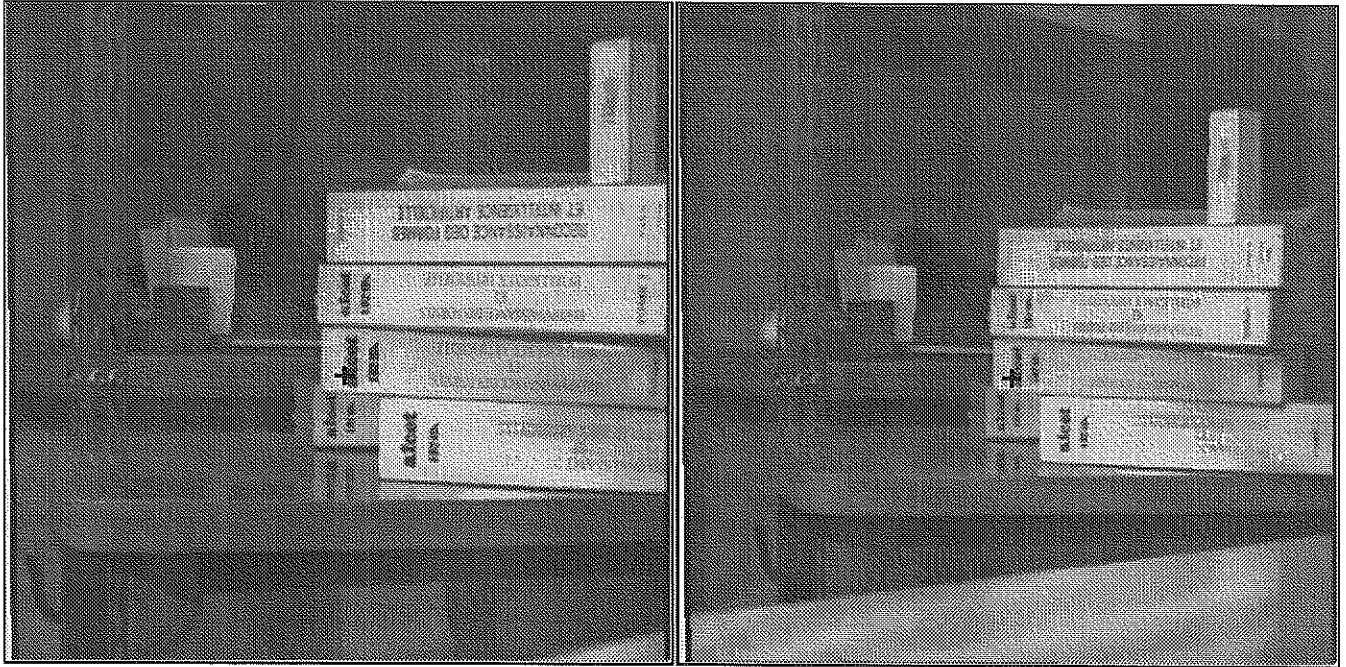


# APPARIEMENT COULEUR

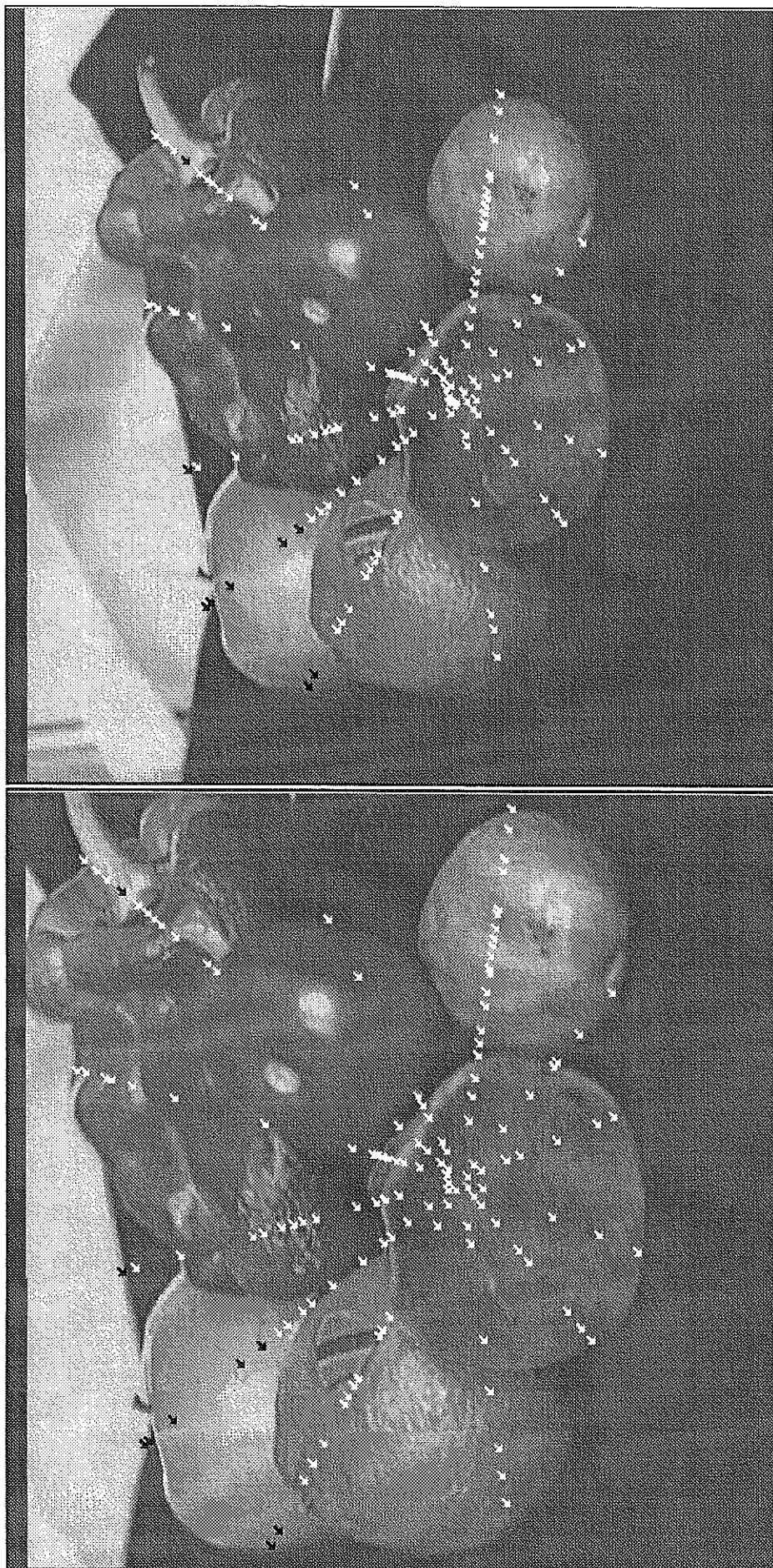




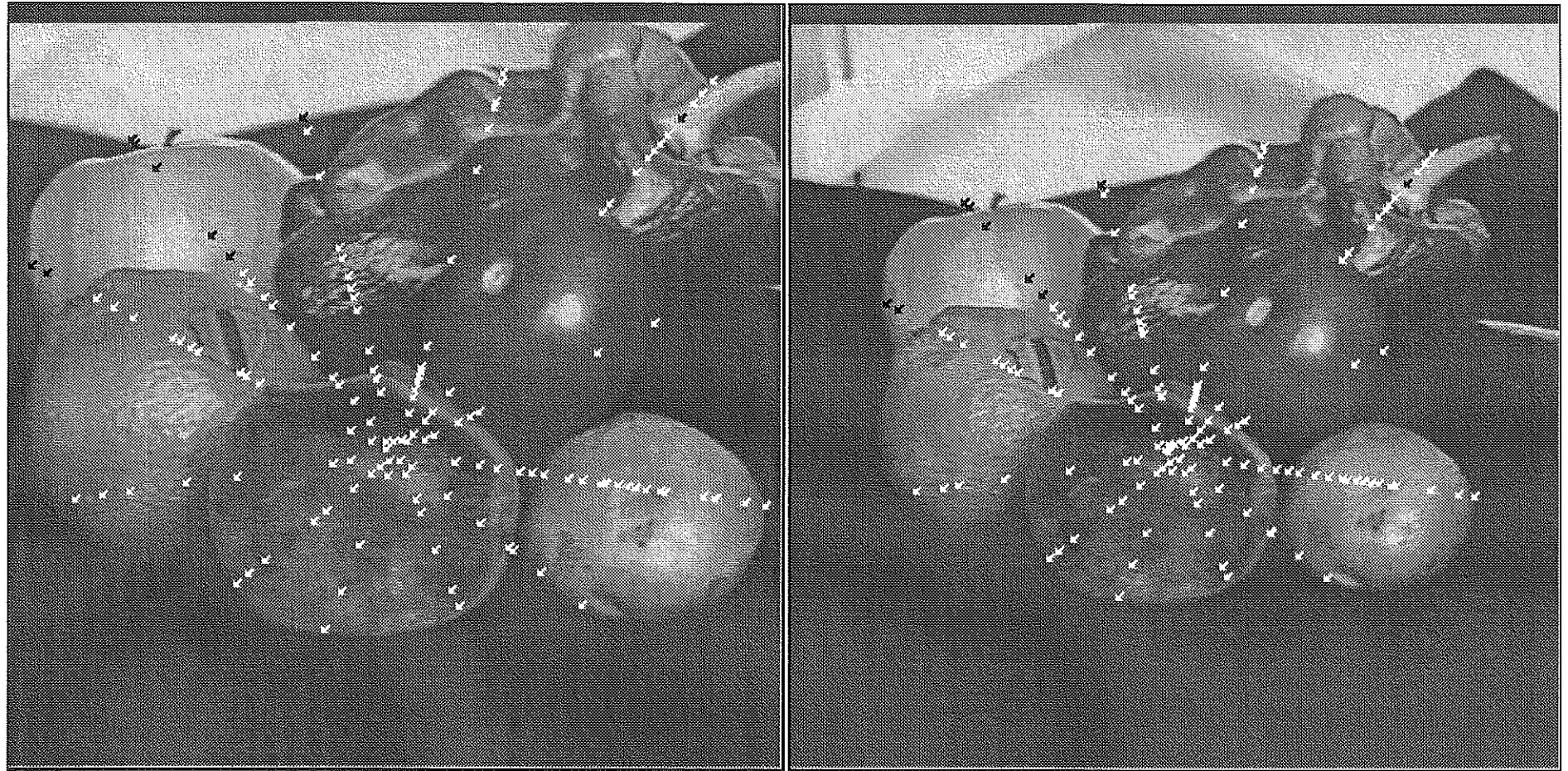
## 4. RESULTATS APPARIEMENT NOIR et BLANC



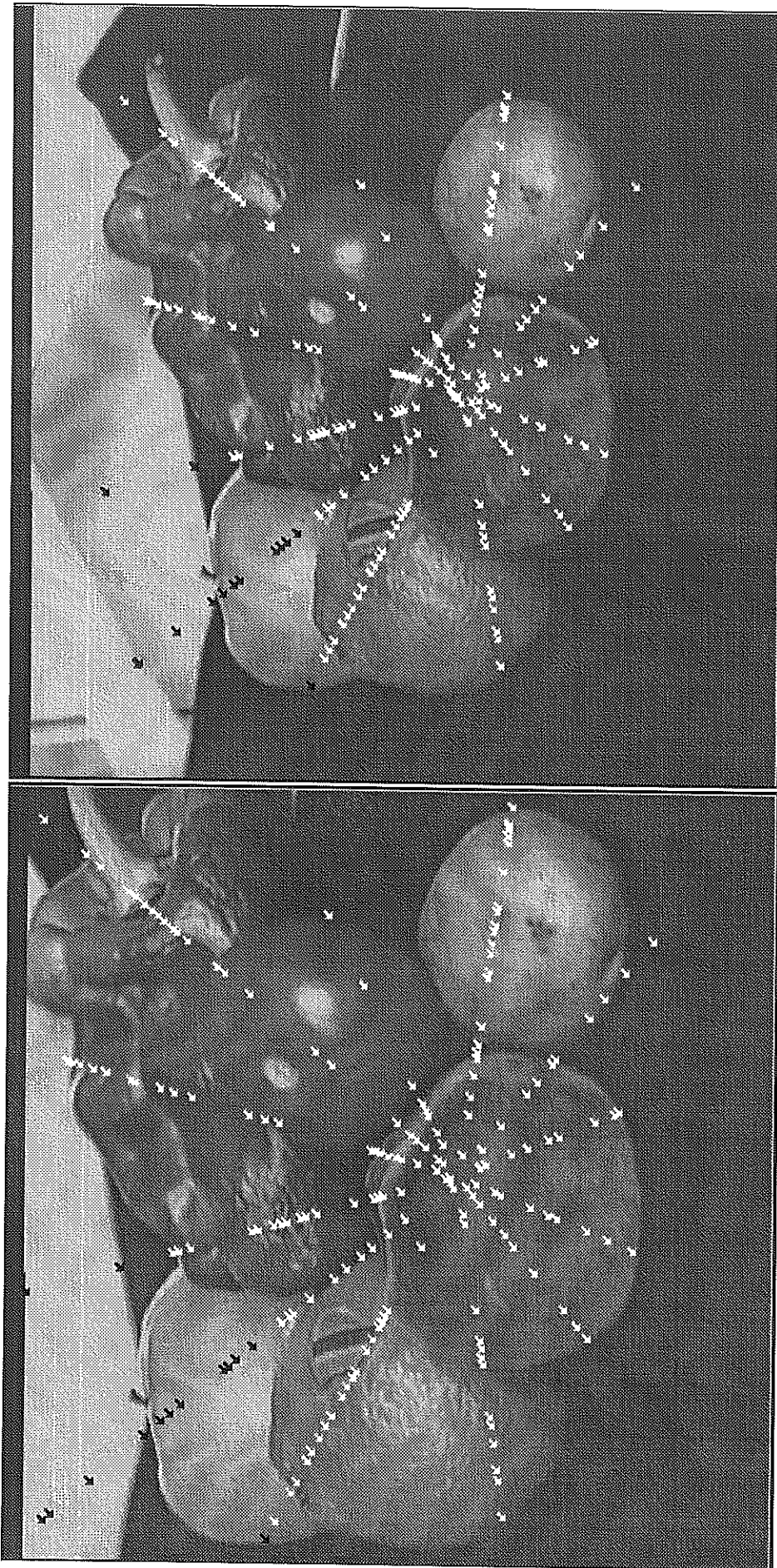
## 4. RESULTATS APPARIEMENT NOIR et BLANC



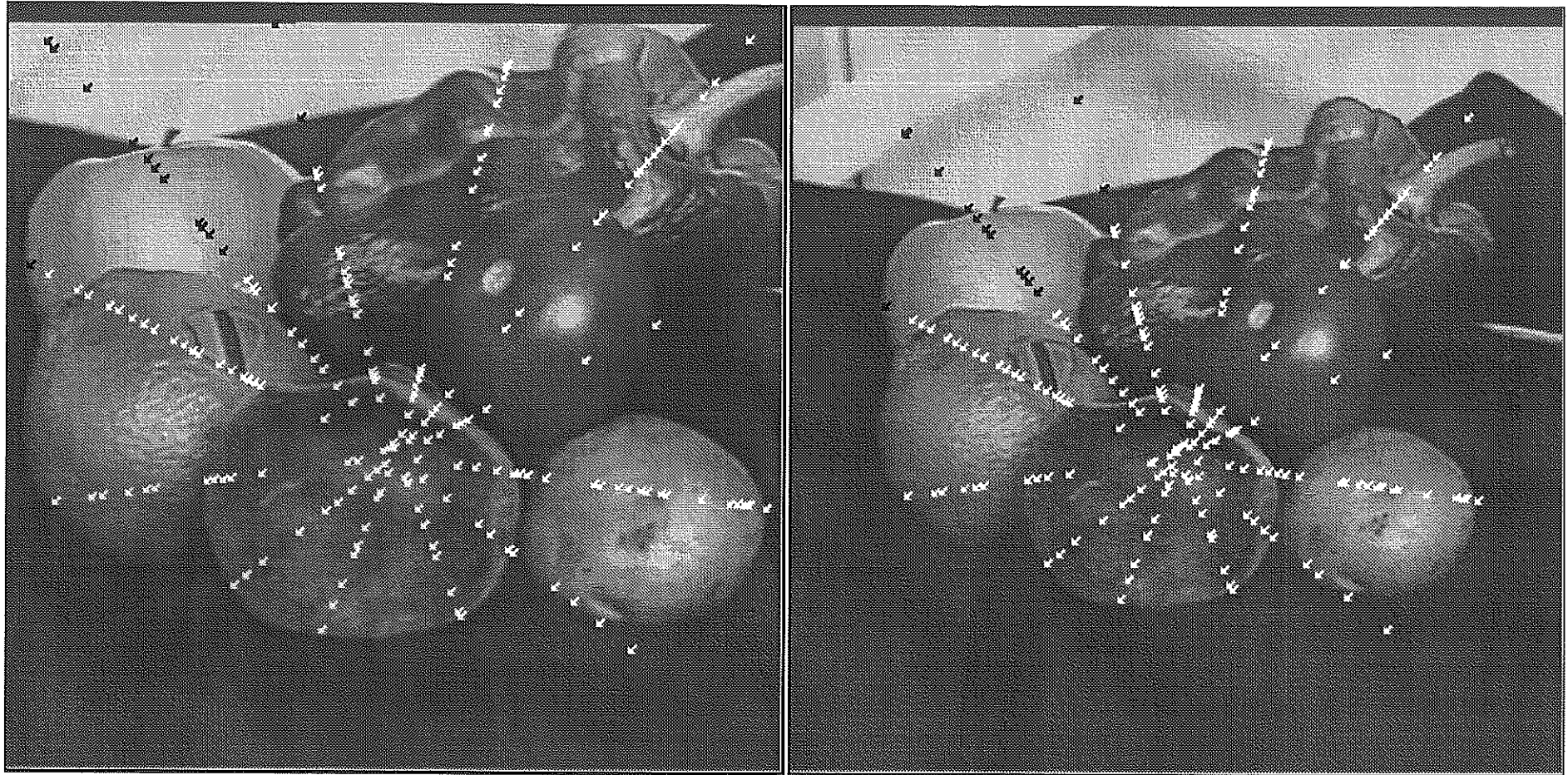
## 4. RESULTATS APPARIEMENT NOIR et BLANC



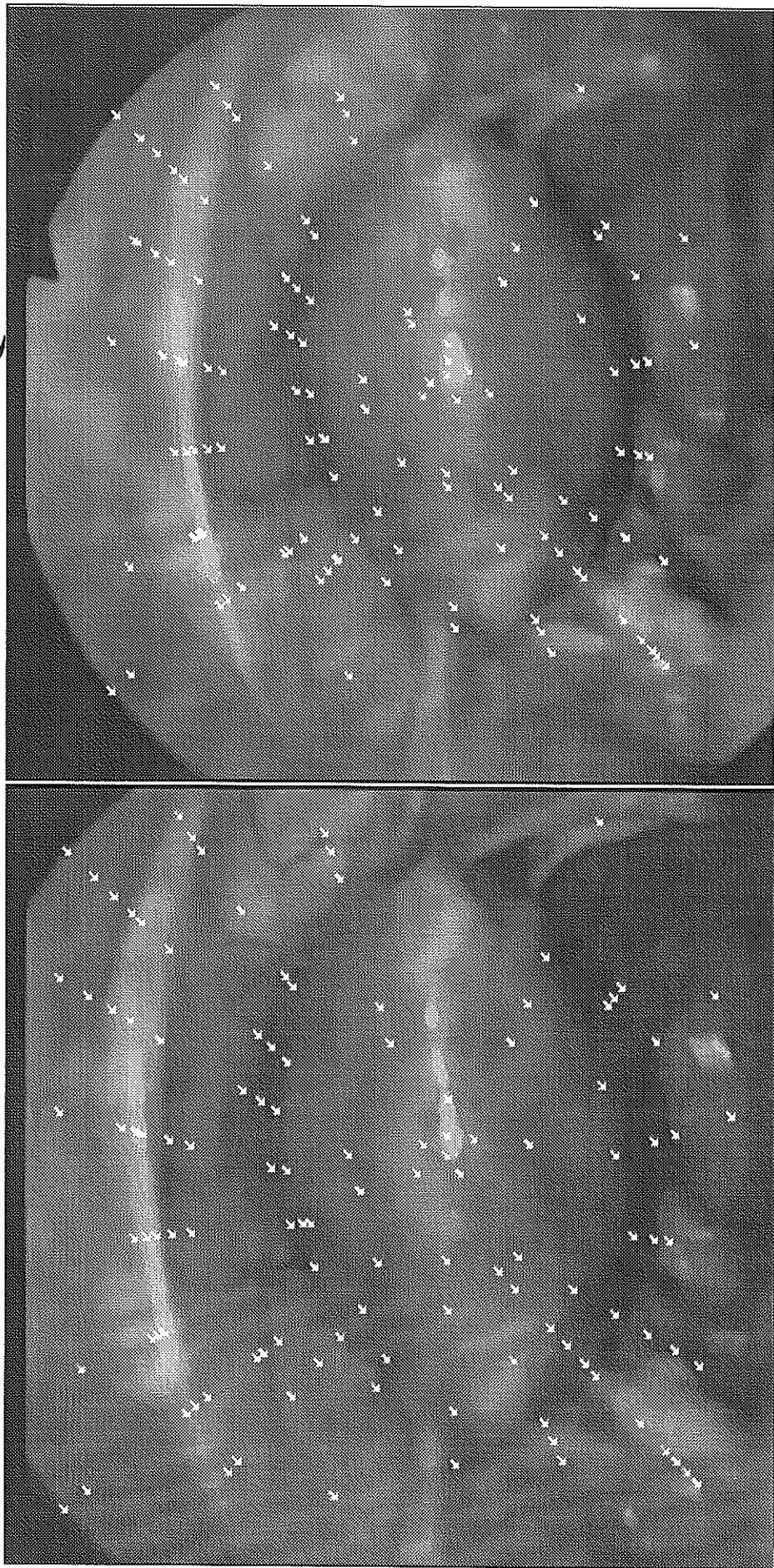
# 4. RESULTATS APPARIEMENT COULEUR



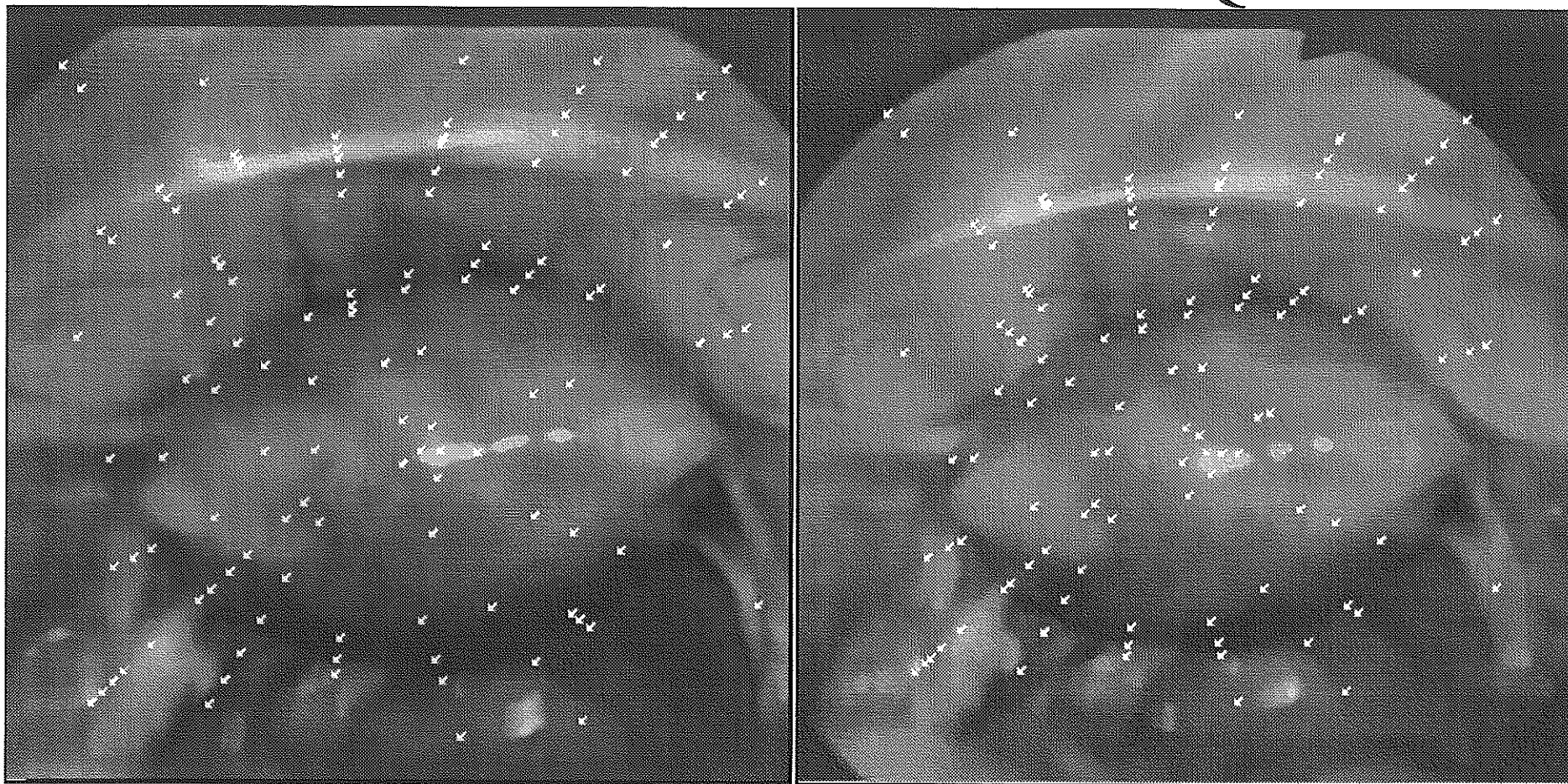
# 4. RESULTATS APPARIEMENT COULEUR



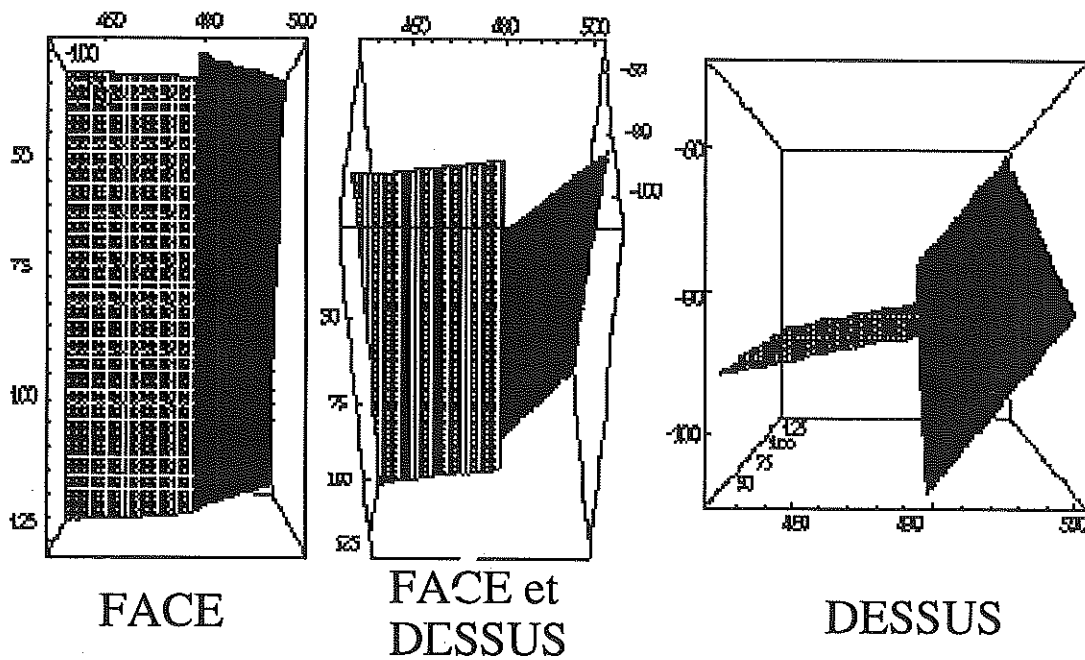
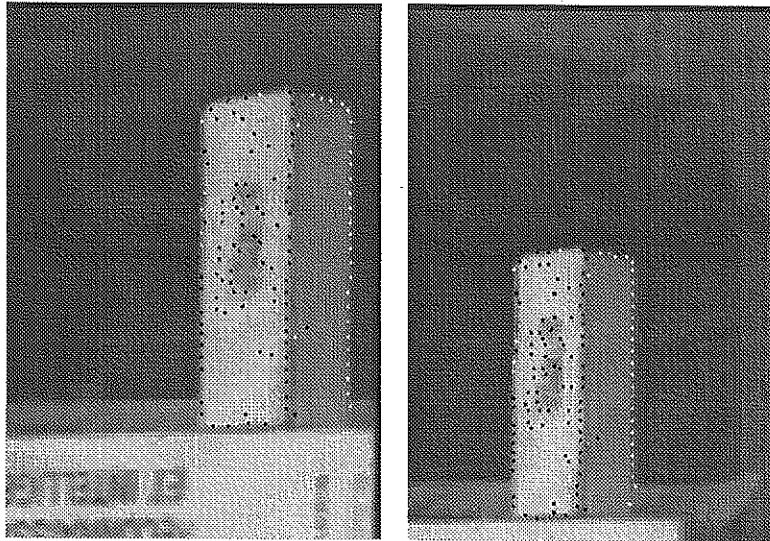
# 4. RESULTATS APPARIEMENT COULEUR SUR DES IMAGES ENDOSCOPIQUES



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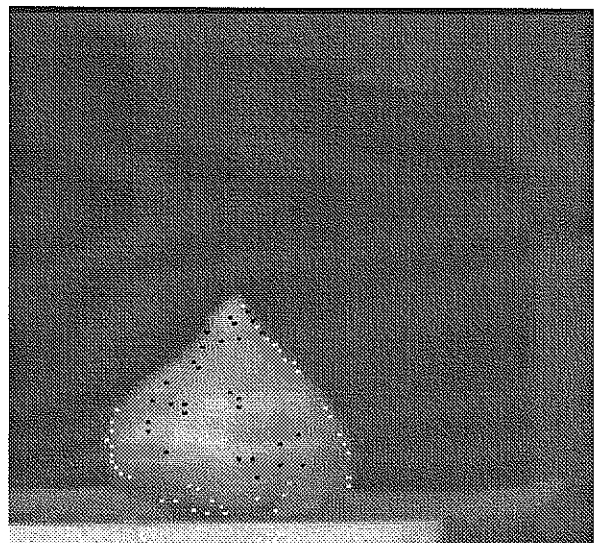
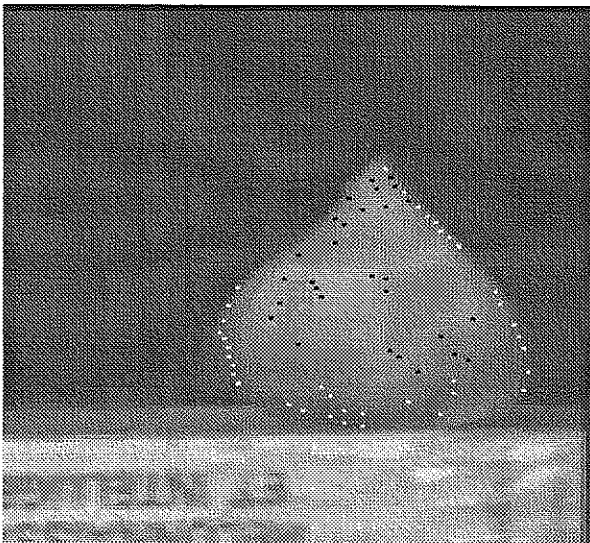
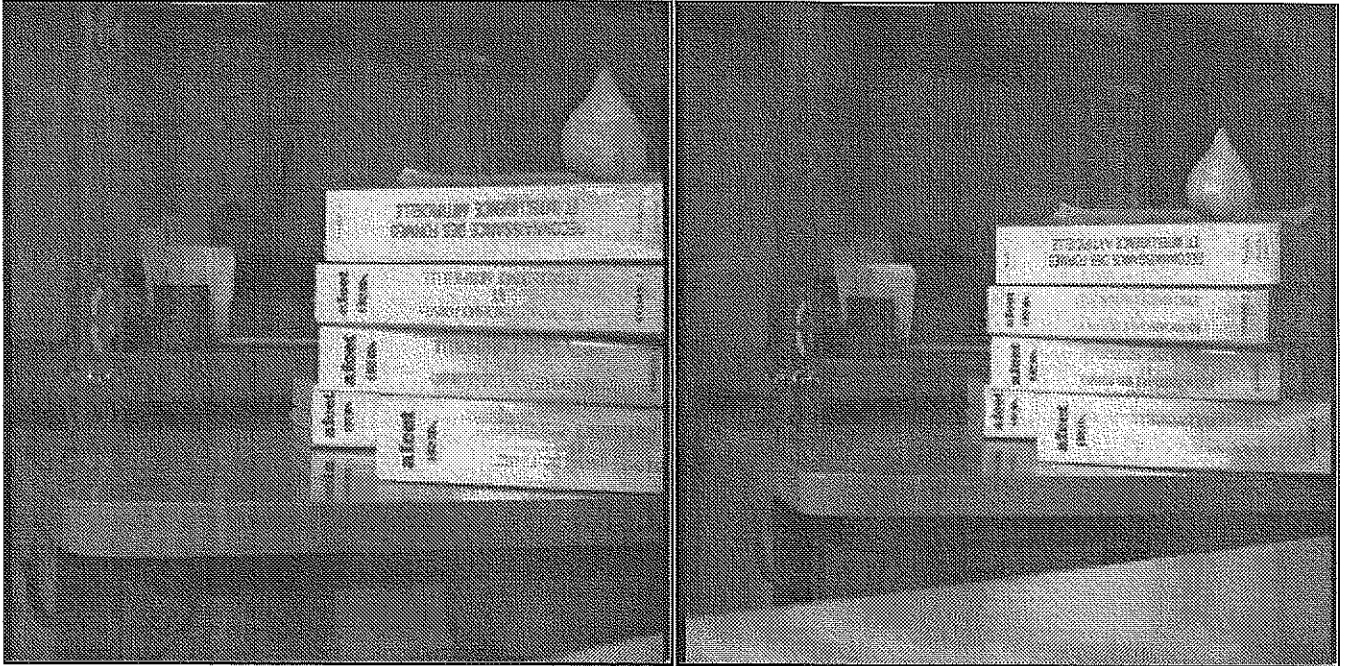
# 1. PARALLELEPIPEDE



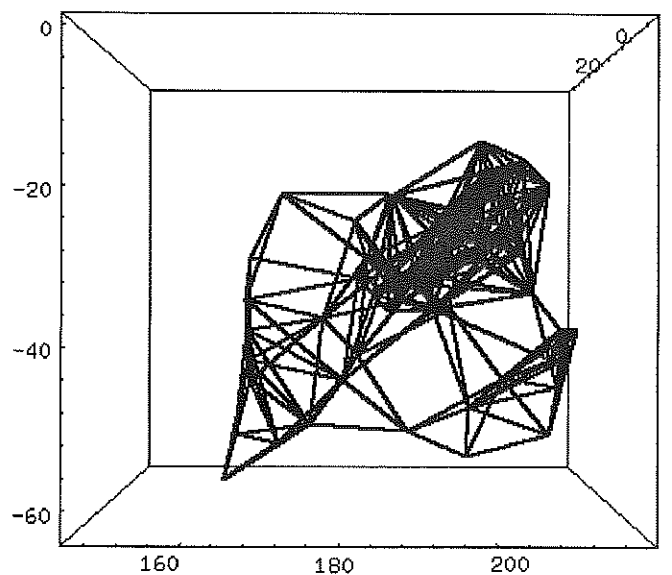
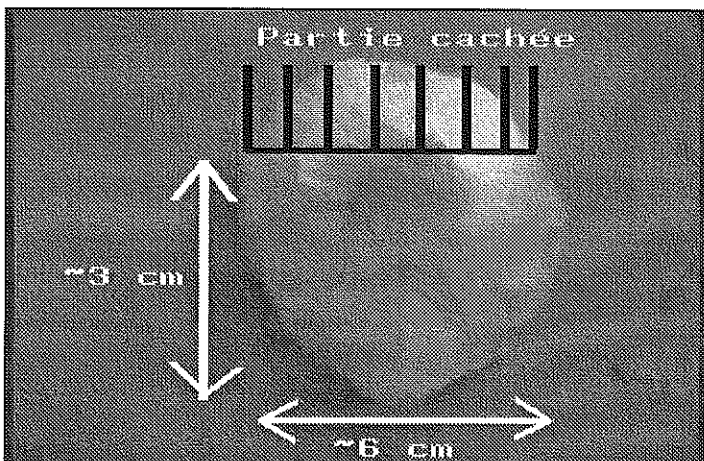
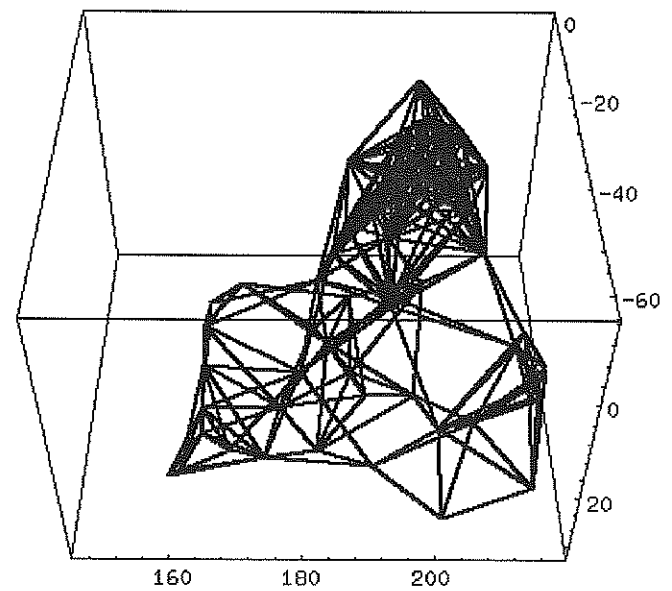
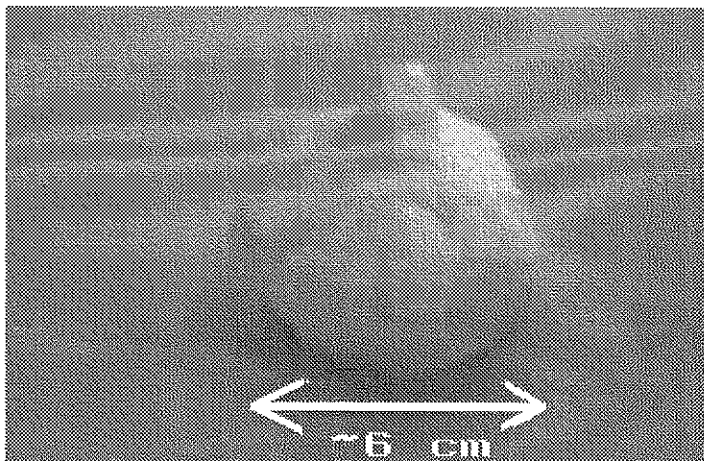
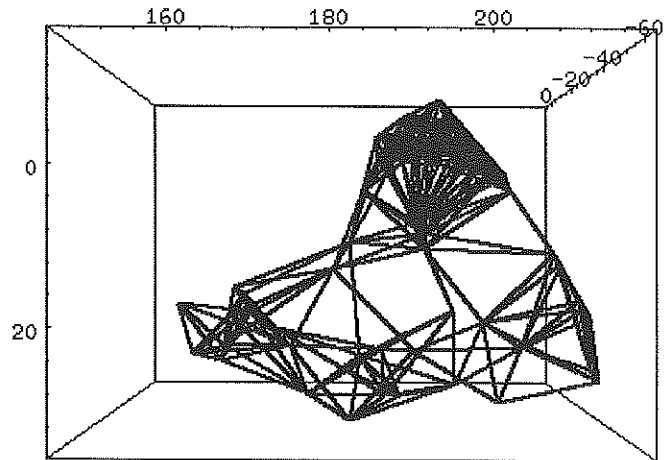
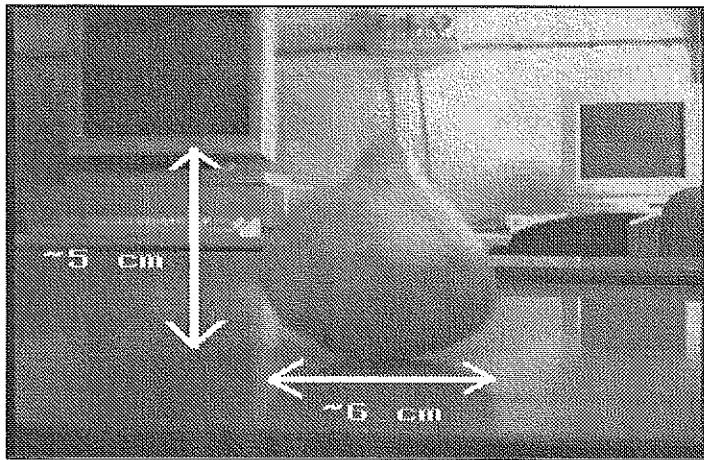
ECART ANGULAIRE: 50°



## 2. OBJET NATUREL : AIL



## 2. OBJET NATUREL : AIL



## VI- CONCLUSION - PERSPECTIVES

### 1. AUGMENTER LA PRECISION:

- CAMERA ET NUMERISEUR  
HAUTE RESOLUTION

- CALIBRAGE DES DISTORSIONS

### 2. APPARIEMENT PLUS GLOBAL

### 3. CAPTEUR SPECIALISE (Brevet CNRS)

2 IMAGES "AXIALES"  
SIMULTANEEES



ENDOSCOPIE OPERATOIRE