Comparison of rigid image registration methods

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INTRODUCTION

Contents

I. Image registration methods

We have two images X and Y that represent the same object taken from different angles and/or at different times.

And the principle of a registration method is to transform the image Y to superimpose each structure that composes it with those of the image X.

- **X** : reference image
- **Y** : processed image

Procedure of Registration method

A. Coherent Point Drift

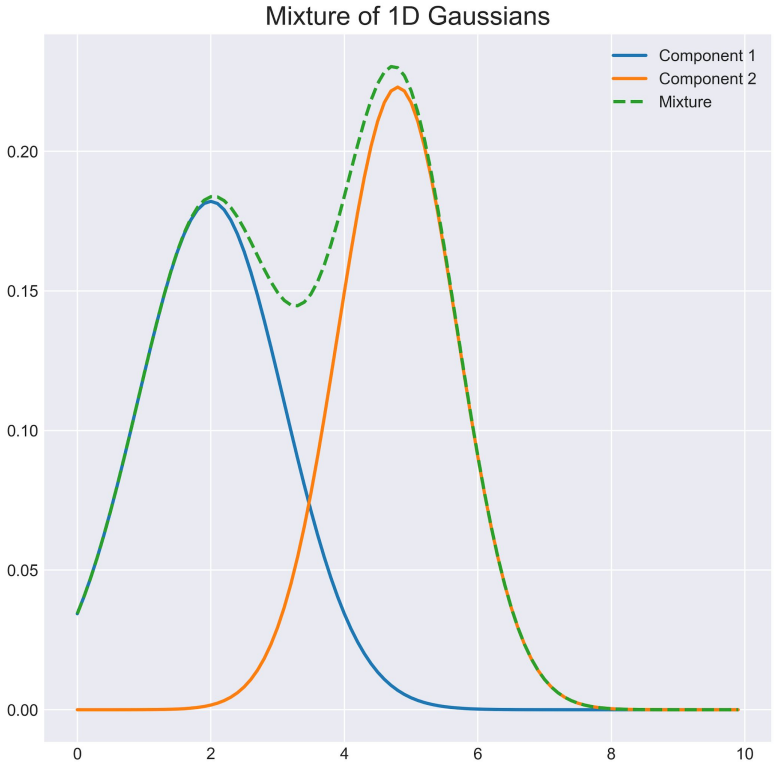
The gaussian mixture model :

The density for one gaussian

$$p(\mathbf{x} \mid m) = \frac{1}{(2\pi\sigma^2)^{D/2}} \exp^{-\frac{\|\mathbf{x}-\mathbf{y}_m\|2}{2\sigma^2}}$$

The density of the model

$$p(\mathbf{x}) = \sum_{m=1}^{M+1} P(m)p(\mathbf{x} \mid m)$$



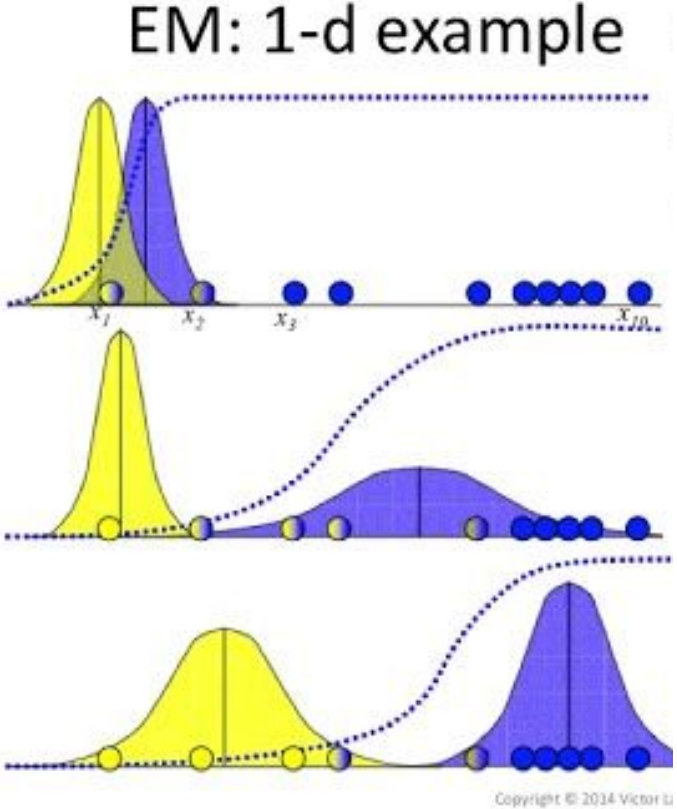
A. Coherent Point Drift

EM algorithm

$$E\left(\theta,\sigma^2\right)=-\sum_{n=1}^{N}\log\sum_{m=1}^{M+1}P(m)p(\mathbf{x}\mid m)$$

$$Q\left(\theta,\sigma^2\right)=\frac{1}{2\sigma^2}\sum_{n=1}^{N}\sum_{m=1}^{M}P^{\text{old}}\ (m\mid\mathbf{x}_n)\left\|\mathbf{x}_n-\mathcal{T}\left(\mathbf{y}_m,\theta\right)\right\|^2$$

$$+\frac{N_{\mathbf{P}}D}{2}\log\sigma^2$$



Result of Coherent Point Drift method on leaves

Image X

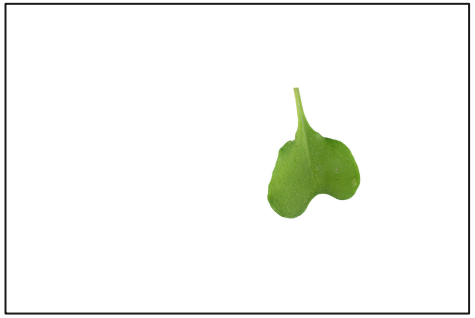
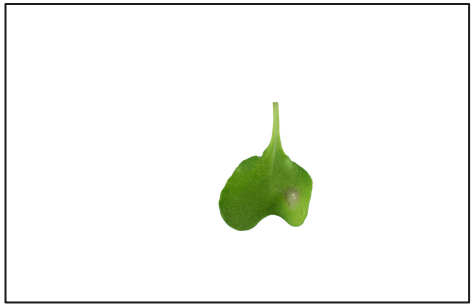


Image Y



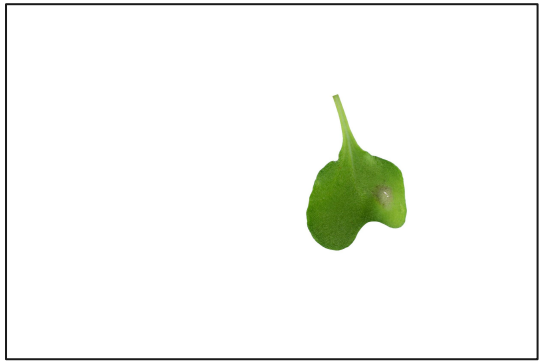


Image registred

B. Mutual Information

Method derived from information theory and based on *Shannon*'s entropy.

Goal : Find the best transformation that maximizes the mutual information between the two images.

$$M(X,Y) = H(X) + H(Y) - H(X,Y)$$

With $H(X) = -E[\log(P(X)]$: the Shannon entropy of X.

➔ The most used optimization method is ***gradient descent.***

Result of Mutual Information method on leaves

Image X

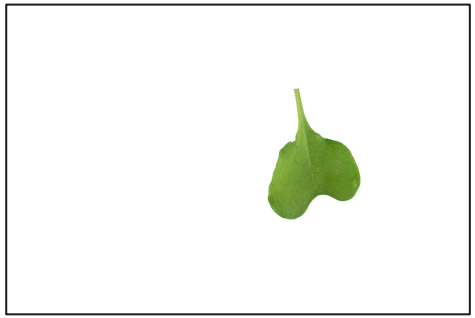
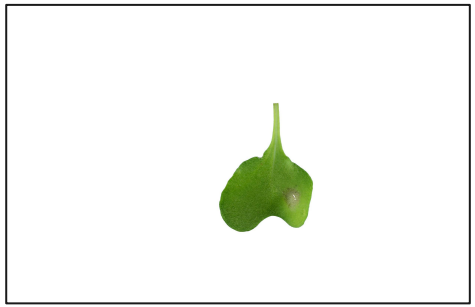
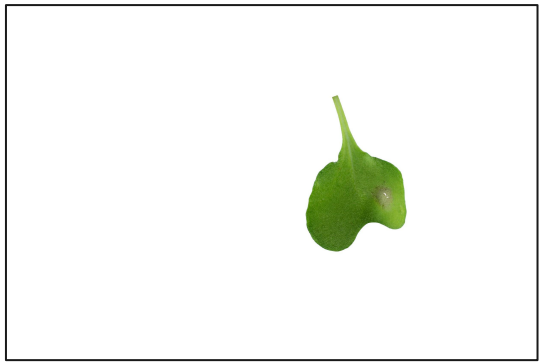


Image y





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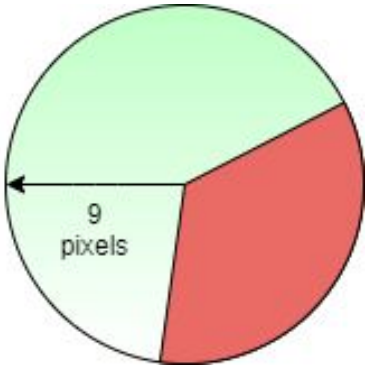
C. ORB

FAST :

- FAST for corner detection :



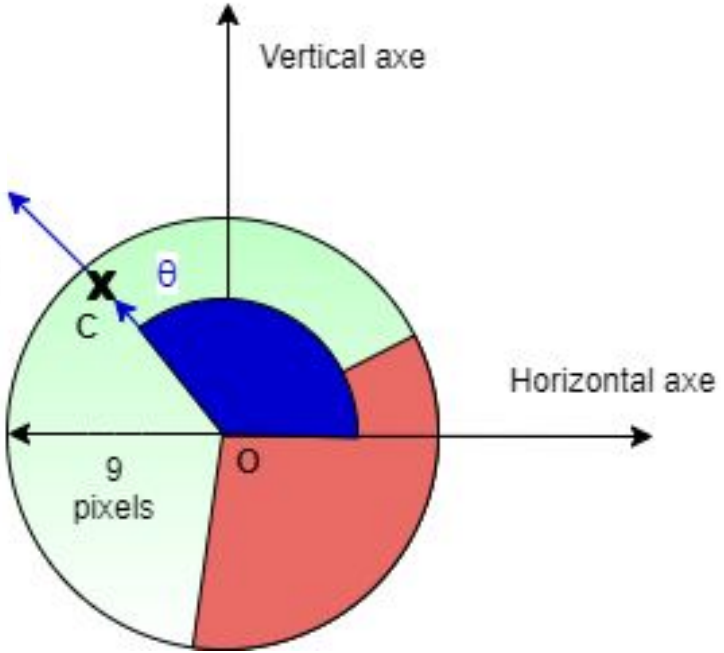
Oriented FAST :

- Orientation of the corner :

$$m_{pq} = \sum_{x,y} x^p y^q I(x,y)$$

$$C = \left(\frac{m_{10}}{m_{00}}, \frac{m_{01}}{m_{00}} \right)$$

$$\theta = \operatorname{atan} 2 \left(m_{01}, m_{10} \right)$$



C. ORB

BRIEF:

$$\tau(\mathbf{p};\mathbf{x},\mathbf{y}) := \begin{cases} 1 & : \mathbf{p}(\mathbf{x}) < \mathbf{p}(\mathbf{y}) \\ 0 & : \mathbf{p}(\mathbf{x}) \geq \mathbf{p}(\mathbf{y}) \end{cases}$$

$$f_n(\mathbf{p}) := \sum_{1 \leq i \leq n} 2^{i-1} \tau\left(\mathbf{p};\mathbf{x}_i,\mathbf{y}_i\right).$$

Steered BRIEF :

$$g_n(\mathbf{p},\theta) := f_n(\mathbf{p}) \mid (\mathbf{x}_i,\mathbf{y}_i)$$

Rotated BRIEF :

Best subset of binary tests

Result of ORB method on leaves

Image X

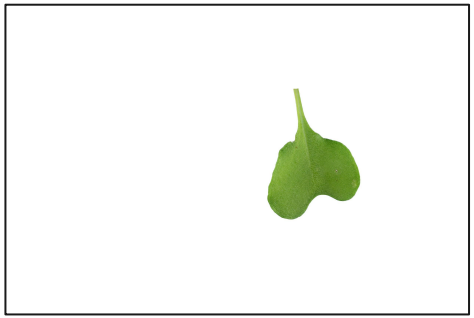
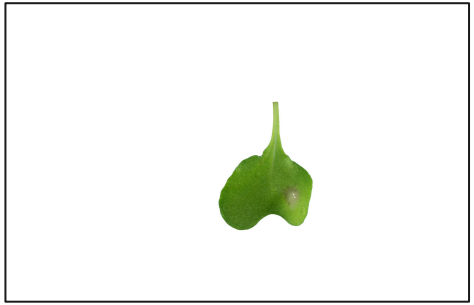
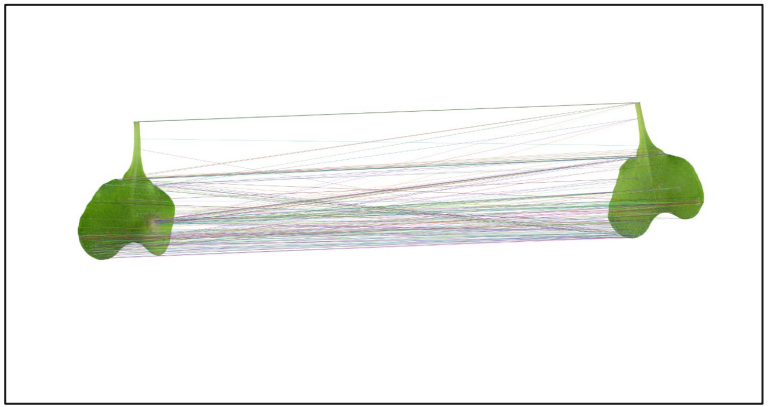


Image Y





Correspondence between the two images

Image X

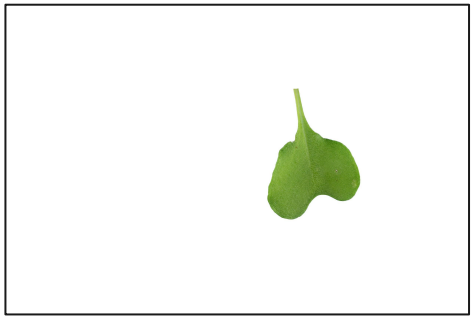
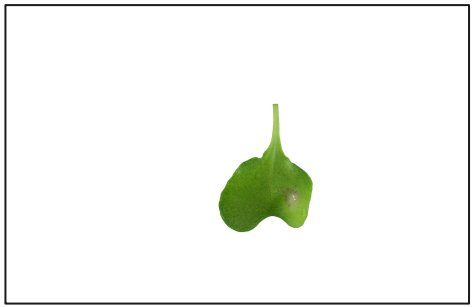


Image Y



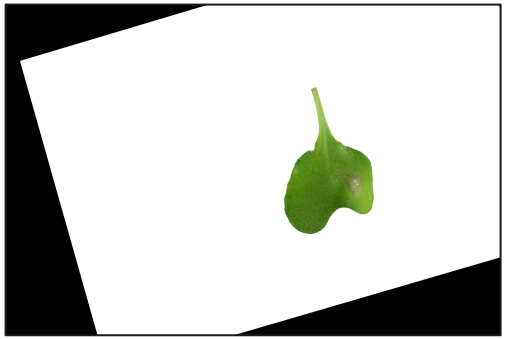


Image registred

II. Application on leaves images

- We worked with **35** plant leaves and applied the 3 registration methods on this sample.

  After We calculate the Root Mean Square Error (RMSE), the Structural Similarity (SSIM) , and the execution time.

➔ We have obtained the following result :

Performances and comparison

	Average RMSE	Average SSIM	Average execution time
ORB	117.8819	0.7688	2.8185
Mutual Information	51.0177	0.9981	1736.3432
Coherent Point Drift	26.4103	0.9765	487.8795

TABLE 1 – Performances and comparison of registration methods.

- ➔ **RMSE** : Coherent Point Drift method
- ➔ **SSIM** : Mutual information method
- ➔ **Execution time** : ORB method
- ➔ **Overall** : Coherent Point Drift method

Conclusion :

- We have studied and compared three registration methods : the ORB method, the Mutual information method, and the Coherent Point Drift method, using RMSE and SSIM as performance and comparison metrics.
- Based on our results, we have concluded that the best method is **Coherent Point Drift method.**

Thanks for attention !