SIFT descriptor to set landmark on biological images

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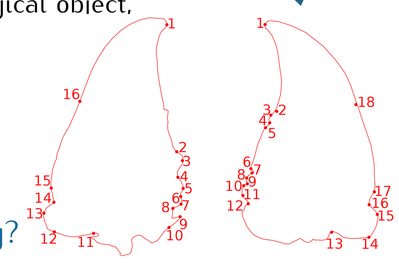
Context

- **Morphometry** analysis is a way to characterize the shape variations of the organisms,
- Morphometric characteristics have been used to evaluate the evolution of an organism, by finding new or sharpening definition of old one,
- **Morphometrics** are also used to **classify** the objects in different groups.

Manual landmarks

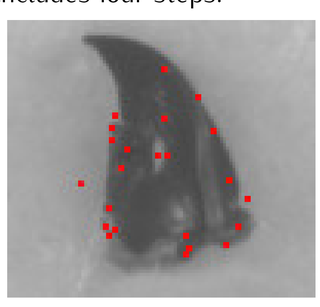
- Morphometric landmarks are points of interest in biological object,
- Landmarks characterize specificities through the shape most often linked to biological information,
- They are usually **defined** by biologists **manually**,
- Images show manual landmarks in **beetle mandibles** belonging to our sample.



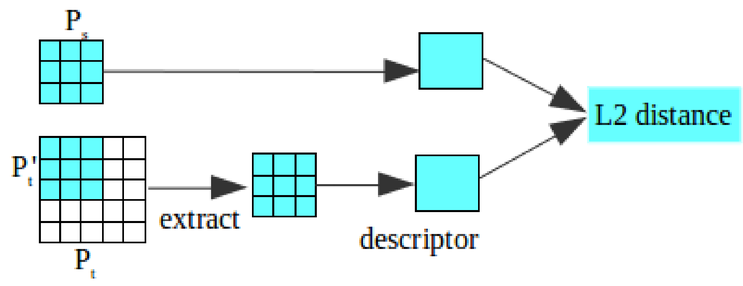
How to locate the landmarks automatically?

SIFT

- SIFT descriptor[4] is used to extract features from images. It includes four steps:
  - → Scale-space extrema detection
  - → Keypoints localization
  - → Orientation assigment
  - → Keypoints descriptor
- **Limitation:** The obtained results from original SIFT method set **many landamark candidates**.
- **Solution:** Reducing the searching space before computing the SIFT descriptors.



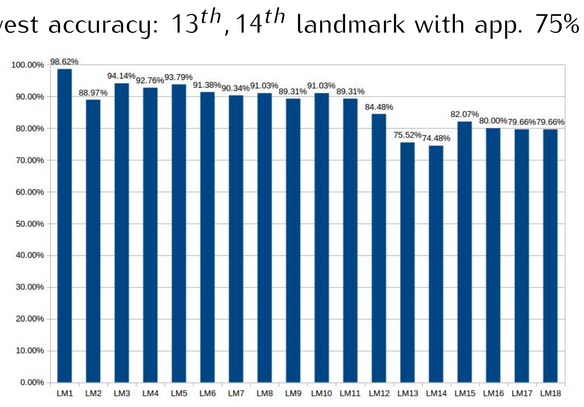
SIFT and landmarks

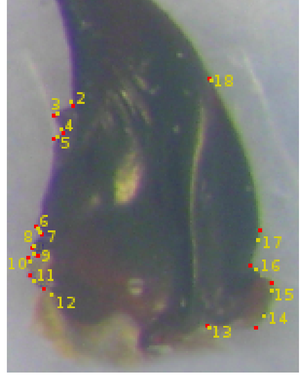


1. A **patch** P_m is initialized at each manual landmark of model image (size of 9×9),
2. Calculating the SIFT descriptor for P_m,
3. At the same position in the scene image, a patch P_s is created (size of 36×36),
4. For each pixel in P_s, a patch P'_s is extracted with the same size than P_m,
5. Calculating the SIFT descriptor for all P'_s,
6. Computing the distance between the descriptor of P_m and each P'_m,
7. At the end, the pixel that has the **minimum distance** with P_m is kept.

Results on right mandibles

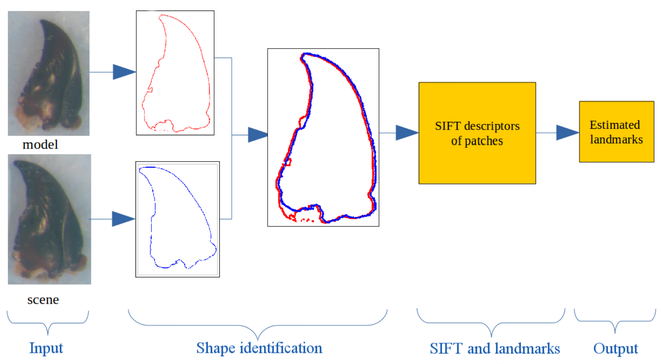
- Highest accuracy: 1^{st} landmark with 98.62%
- Lowest accuracy: $13^{th}, 14^{th}$ landmark with app. 75%





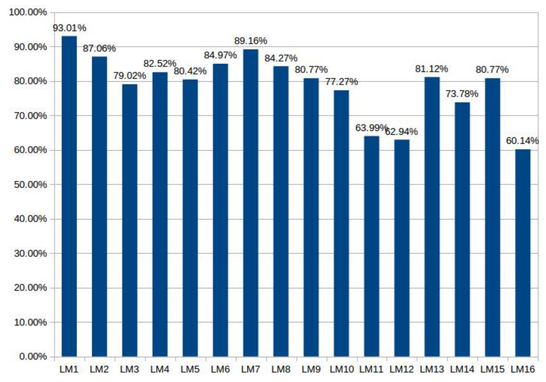
Proposed method

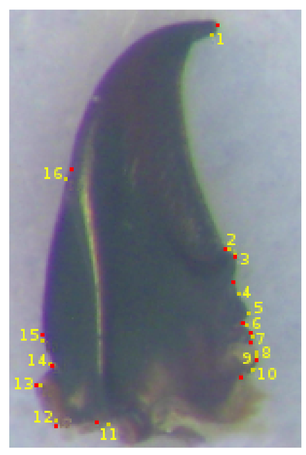
- **Input:**
  - → Model image
  - → Model manual landmarks
  - → Scene image
- **Output:**
  - → Landmarks of scene image
- **Steps:**
  - → Shape identification: segmentation and registration
  - → SIFT and landmarks



Results on left mandibles

- Highest accuracy: 1^{st} landmark with 93.01%
- Lowest accuracy: $11^{th}, 12^{th}$ and 16^{th} landmark from 60% to app. 63%





Segmentation

1. Converting the image to binary one by applying a **threshold** determined by histogram analysis[3].
2. Contours points are extracted by Canny algorithm[1]. The thresholds ratio in Canny: $T_{lower} = (1/3) \times T_{upper}$, in which T_{lower} equals to the threshold value in step 1.

Registration

Model and scene images are segmented to extract the contours points. The contours points are registered by applying **P**rincipal **C**omponent **A**nalysis[2] **I**teration (PCAI).

1. Compute the centroid point and principal axis of each list of contour points,
2. Compute the **translation** and **rotation** values between two lists of contour points,
3. **Register** the two lists of contour points,
4. Sort the contour points of scene image followed y-direction,
5. Select a subset of contour points of scene image and repeat step 1,
6. PCAI stop automatically when the **angle difference** between two lists of contour points is less than 1.5 **degree**.

Conclusions

- A solution based on SIFT descriptor for landmark estimation is presented,
- The results show that method **succeed in locating** all landmarks in request images,
- The accuracy of method is sufficient to be **proposed to biologists** as a **replacement of manual positioning**, and to characterize the shape.

Bibliography

[1] J. Canny. A computational approach to edge detection. *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, (6):679–698, 1986.

[2] I. Jolliffe. *Principal component analysis*. Wiley Online Library, 2002.

[3] L. Lê Vãnh, M. Beurton-Aimar, J. Salmon, A. Marie, and N. Parisey. Estimating landmarks on 2d images of beetle mandibles. *WSCG*, 2016.

[4] D. G. Lowe. Distinctive image features from scale-invariant keypoints. *International journal of computer vision*, 60(2):91–110, 2004.