SIFT descriptor to set landmarks on biological images

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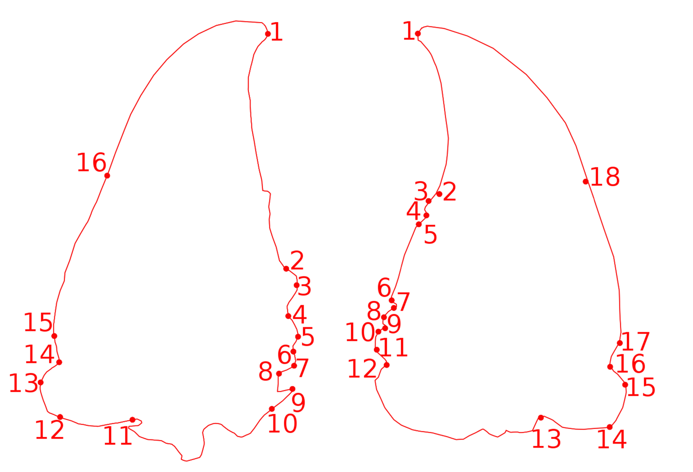
Context

Morphometry analysis is a way to distinguish the characteristics of organisms, i.e *shape, size, form,...*. It is used to appreciate the covariances between the ecological factors and the organisms. Landmark-based morphometry is known as one of the approaches to analyze the characteristics of organisms. Finding enough landmarks can give to biologists a comprehensive description of the organism. This work focuses on the automatic identification of landmarks on 2D biological images.

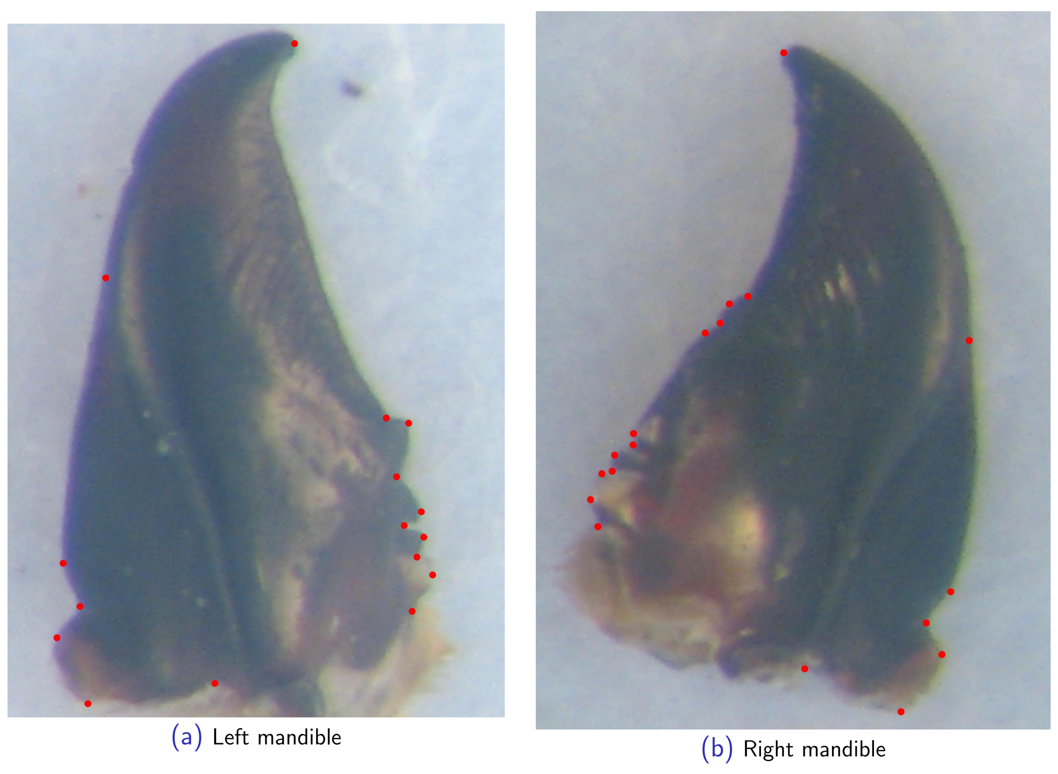
Landmarks

- Morphometric landmarks are points of interest in the biological object. They usually stay along the outline of the image.
- Landmarks characterize specificities through the shape most often linked to biological information,
- They are usually **defined manually** by biologists,
- Images at the right side show manual landmarks in **beetle mandibles** belonging to our sample:
  16 and 18 manual landmarks have been defined for each left mandible and right mandible, respectively.



How to locate the landmarks automatically?

Mandibles and manual landmarks

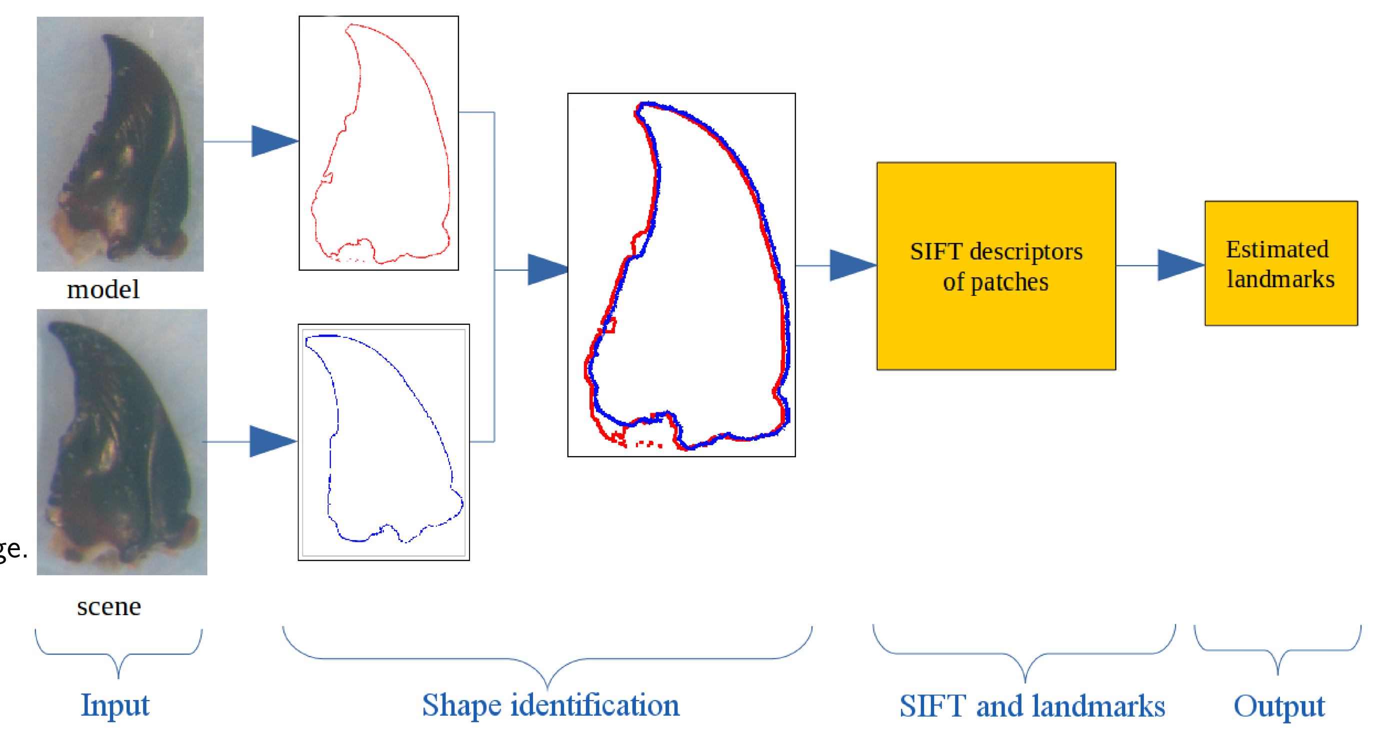


(a) Left mandible (b) Right mandible

Figure: Example of beetle mandibles from the studied data set with manual landmarks.

Proposed method

- **Input:**
  - A model image
  - The manual landmarks of model image
  - A scene image
- **Output:**
  - Landmarks of scene image
- **Steps:**
  - Shape identification: segmentation and registration
  - SIFT and landmarks: Extract the patches, calculate the SIFT descriptors and estimate the coordinates of landmarks on the scene image.



Segmentation

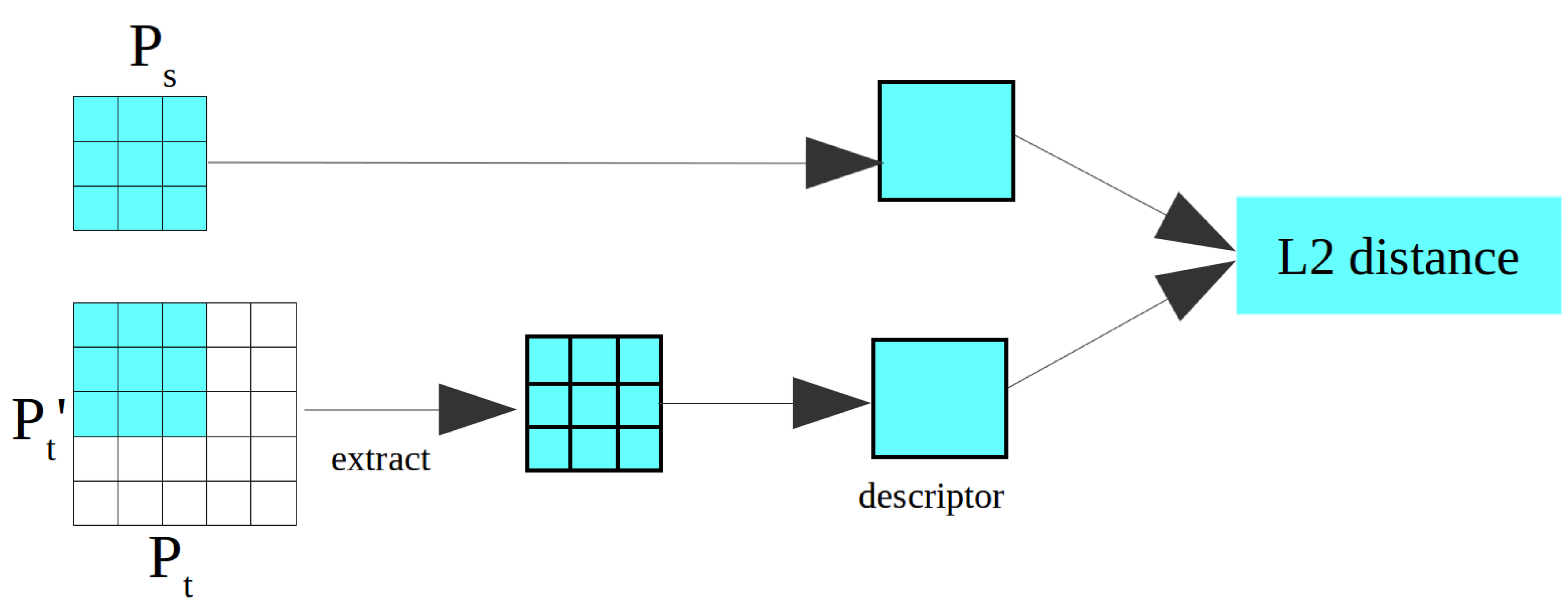
1. Converting the image to binary one by applying a threshold determined by histogram analysis [1],
2. Contours points are extracted by Canny algorithm [2]. The thresholds ratio in Canny: $T_{lower} = (1/3) \times T^{upper}$, in which T^{lower} equals to the threshold value in step 1.

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 [3] **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**.

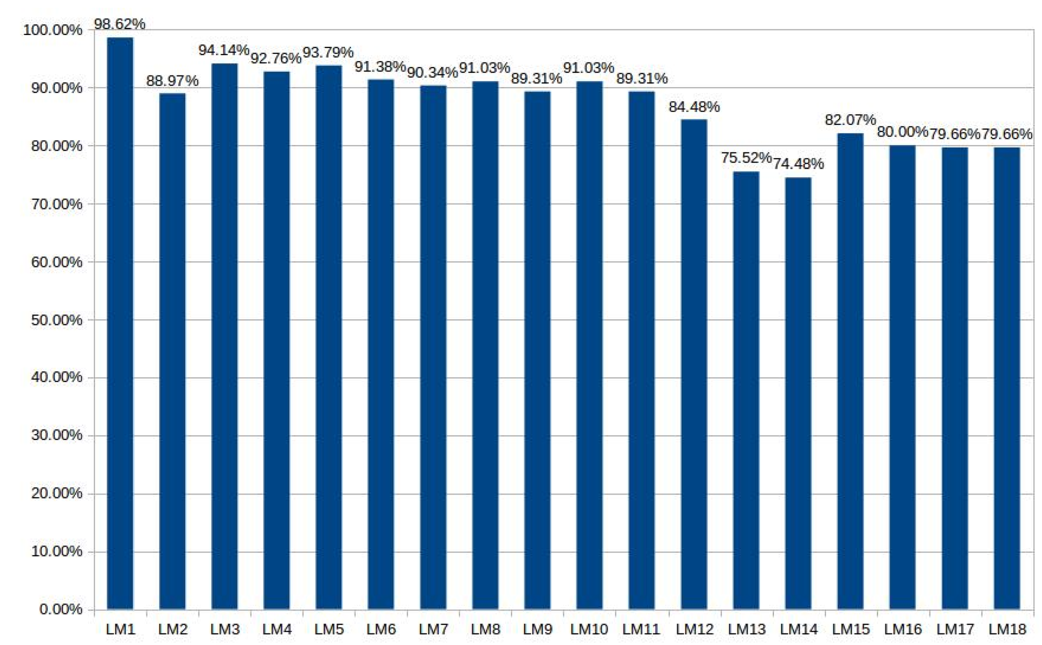
SIFT and landmarks

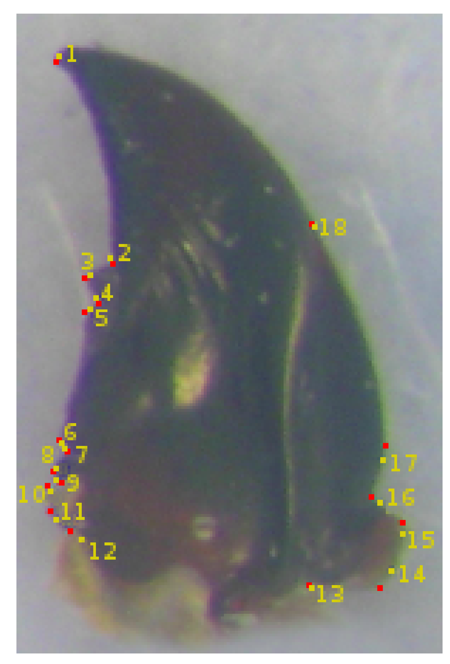


1. A **patch** P_s is initialized at each manual landmark of model image (size of 9×9),
2. Calculating the SIFT[4] descriptor for P_s,
3. At the same position in the scene image, a patch P_t is created (size of 36×36),
4. For each pixel in P_t, a patch P'_t is extracted with the same size than P_s,
5.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

Results on right mandibles

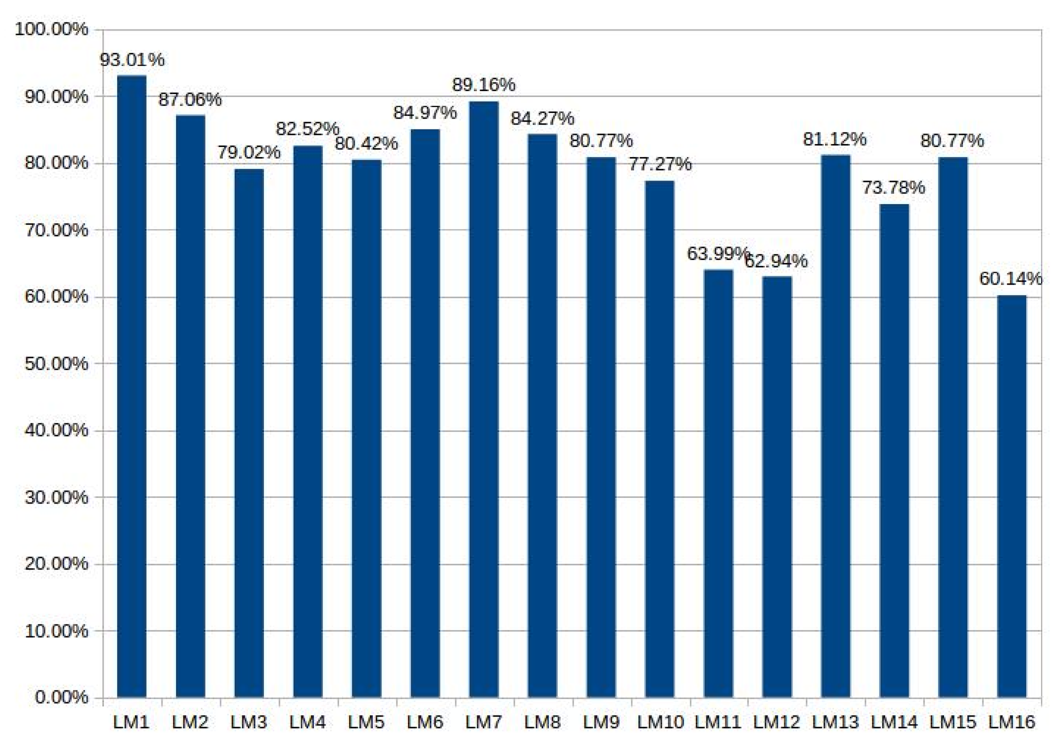
- Highest accuracy: 1^{st} landmark with 98.62%
- Lowest accuracy: $13^{th}, 14^{th}$ landmark with app. 75%

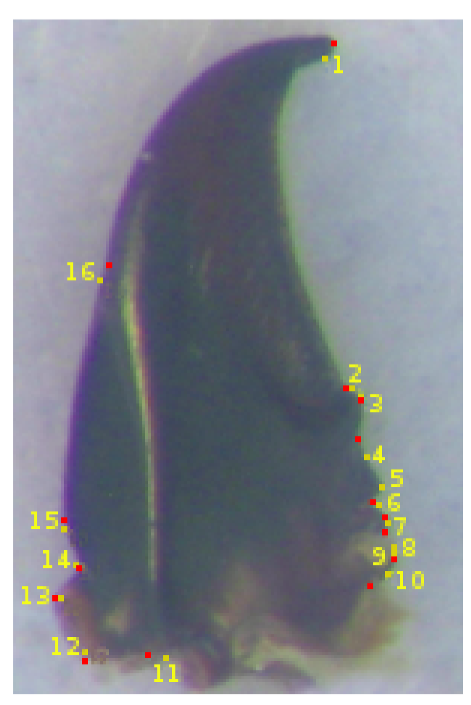




Results on left mandibles

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





Conclusion

- 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.

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