Morphometry landmarks detection by convolutional neural network

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***Abstract*—Morphometric analysis is general method applied on organisms and are useful to appraise the covariances between the ecological factors and the organisms(shape, size, form,...). In which, landmark-based morphometric is known as one of the approaches to analyze the characteristics of organisms. Finding enough the landmarks can give to the biologist a comprehensive description of organism shape. In this study, we propose a convolutional neural network (CNN) to predict the landmarks on biological images. The network is designed as a pipeline of the layers, it was trained with a set of manually landmarks examples. Then, the network is used to provide the morphometric landmarks on biological images automatically. The coordinates of predicted landmarks are evaluated by calculating the correlation coefficient with the manual coordinates which given by the biologists. Besides, the evaluations of the distances between predicted and manual landmarks are also given. The network is implemented by Python on Lassagne framework.**

***Index Terms*—Morphometry, biological, landmarks, CNN**

I. Introduction

Morphometry analysis refers to measure the topography of an object, a notion that includes the shape and size [**?**]. Morphometry analysis is generally applied to organisms. In biology, the biologist can work with several pieces of information from organisms such as lengths, widths, masses, angles,... to analyze the interaction of environment to the developmental of organisms. Besides the traditional information, the landmark is known as one of the characteristics to analyze the shape. Instead of collecting all information, the shape is determined by a finite set of points, called landmarks. The landmarks are the points that store the important information about the shape of the object, for example, four corners of the rectangle are four landmarks of a rectangle. Normally, the landmarks are along on the outline of the object but in some special cases, it has been defined inside the object. Morphometry landmarks are a kind of points-of-interest, they are directly linked to the animal anatomy. In our study, the morphometric landmarks are specific points defined by the biologists. They are used in many biological studies and include the classification tasks. Manual landmarks identification is time-consuming and difficult to re-procedure.

This work introduces a method for automatic detection the landmarks on biological images. The main idea consists design and trains a convolutional neural network [**?**] with a set of manual landmarks. By this way, the trained network will be able to detect the morphometry landmarks on biological images. The dataset that used to study including 293 beetles images from Brittany lands. All the images are presented in RGB color with two dimensional. For each beetle, the biologists took images of five parts: left and right mandibles, head, body, and pronotum. For every image, a set of landmarks has been manually determined by experts. In the last our work, a method has been presented to determine the landmarks on left and right mandibles. This method is based on the image processing techniques [**?**]. In the context of this work, we work on the dataset of pronotum images (Fig.1). For each pronotum image, a set of 8 manual landmarks have been set by the biologists. The coordinates of manual landmarks as the input to train the network. During the first phase, a number of 260 images and their manual landmarks are used to train and validate the network. The remaining images are used to evaluate the output model of the network in the second phase.

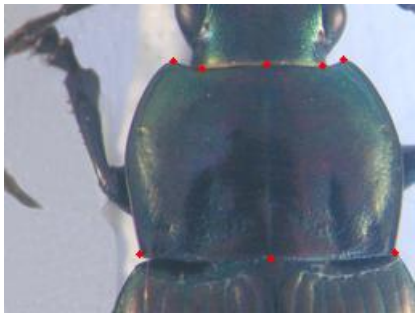

Fig. 1. An example of pronotum with manual landmarks

In the next section, we study several related works to determine the landmarks on 2D images by CNN. Section 3 presents the network, its parameters, and the implementation. All the experiments and analysing the results will be detailed in section 4.

II. Related works

In recent years, deep learning is known as a solution for computer vision literature. Using convolutional network to learn the vision features or to detect the important features on

the images have achieved better results in many domains such as image classification [**?**], face detection and pose estimation [**?**], handwritten detection [**?**] and key points (landmarks) identification [**?**]. The landmarks are not only used in biology, they appear in many domains with many applications. In the field of facial keypoint detection, Yi Sun et al. [**?**] proposed cascaded convolutional networks to predict five facial points (points stay on the human face): *left eye center, right eye center, nose, left mouth corner, and right mouth corner*. They cascade three levels of the convolutional network to predict the facial points: In the first level, the networks are designed to predict several landmarks together by covering the whole face; the networks in the second and the third level are used to predict each landmark on the face. They take the patches centered at the predicted positions of previous levels as input and try to improve the accuracy of predicted positions.(them mot bai nua).

In biology field, Cintas et al [**?**] has introduced a network to predict the landmarks on human ears. The network was designed to receive the images with the size of 96×96 as the inputs. After training, the network has the ability to predict 45 landmarks and semi-landmarks on human ears. In the proposed architecture, the network with three times repeated of a structure includes two convolutional layers with the filters, followed by maximum pooling and dropout layers. The structures then adding two full-connected layers and a dropout layer. At the end, an output layer with 90 output units corresponding with 45 landmarks is hired to provide the position of the predicted landmarks.

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$$a + b = \gamma \tag{1}$$

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TABLE I
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	Table column subhead	***Subhead***	***Subhead***
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[a]Sample of a Table footnote.

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ACKNOWLEDGMENT

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