Towards Setting up of an Automatic Recognition System for Vertebrae and Opercular Anomalies in Reared Gilthead Seabream (*Sparus aurata*)

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Abstract

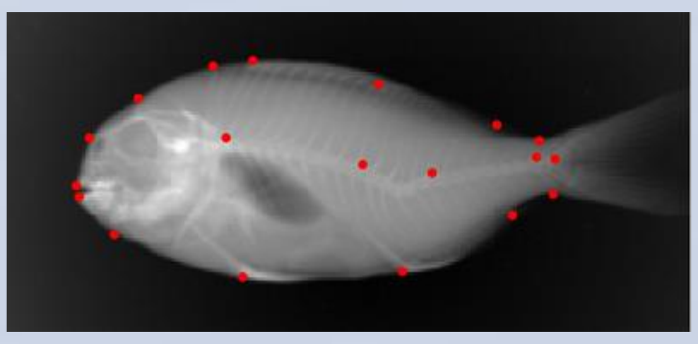
Present tools for the recognition of deformation in the fish are mainly based on the application of Geometric Morphometrics that requires the manual selection of homologous landmark points in the form of x and y coordinates on fish' images, which again is a time consuming task that demands expertise and practice with mathematical modelling. The aim of this research is the setting up of an automatic recognition program developed by Geometric Morphometrics and Artificial Intelligence, in order to accurately estimate the percentage and severity of deformed gilthead seabream from digital radiographs in a sound and rapid way, without the need for manual inputs.

Introduction

- In recent years, an oversupply due to increased production efforts have led to a decline in seabream price value [1].
- In order to secure future markets and value without the expansion of production efforts, farmers and businesses should focus on ameliorating the morphological quality of their current production.
- Major economic losses are directly due to the development of skeletal disorders altering the external shape of reared seabream, i.e. opercular and vertebral column deformities.
- Fish with deformities are rejected by the potential retailers or customers thereby representing a significant economic loss for the fish farmers [4].
- Tedious technical effort and time is required to manually cull out the deformed fish from the productive cycle, which should be done as early as possible in order to not waste resources on growing suboptimal fish.
- Automatic sorting of deformed fish could represent an essential tool used to reduce the time and costs of manual selection and elimination of severely deformed fish from the reared stock, as well as be used to rapidly identify the best practices to reduce the deformation rate.

Materials and Methods

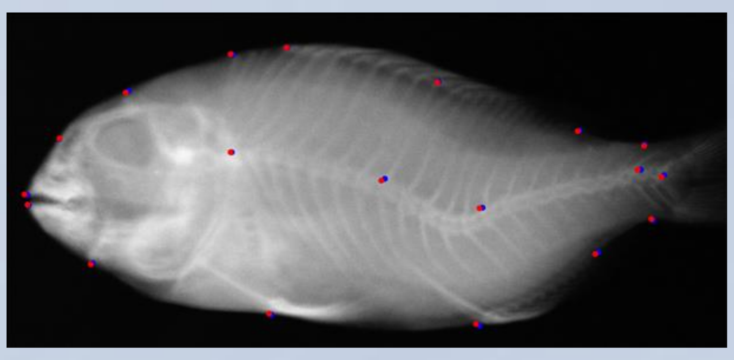
- **Dataset description:** Dataset consisted of radiograph images (digital DXS Pro X-ray, Bruker) of 875 (mean weight 55g) randomly sampled seabream reared at the Instituto Portugues do Mar e da Atmosfera in Olhao Portugal. Radiograph images were used to perform skeletal analysis [3]. Manually selected 19 homologous landmarks points [2] in the form of *x,y* coordinates on each image are chosen for morphometric (shape) analysis in order to characterize each specimen. Images were uploaded and annotated using Cytomine web interface tool [6].

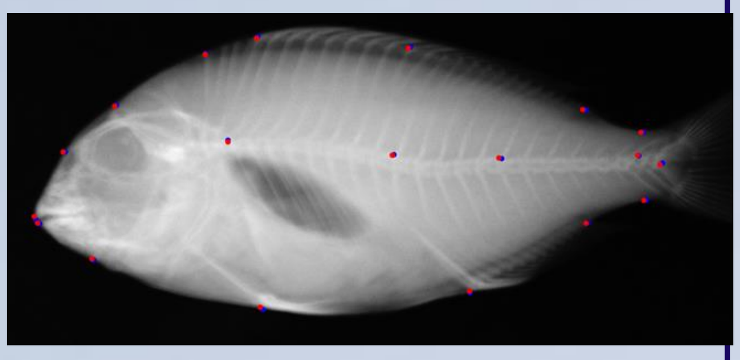


- **AI topology**: A '*Deep Learning*' based Convolutional Neural Network (CNN) called U-Net [5] is trained in supervised manner (i.e. landmark points as labels) to automatically predict the landmark locations.
- **Protocol:** To train the CNN, image dataset is split *into train, validation* and *test* sets. Labelled train set is presented to the CNN for learning; the validation set is using for parameter optimization (fine tuning) and the test set is used to evaluate the performance of the trained CNN.
- **Evaluation metrics**: A probability heatmap based output is expected from the trained CNN which signifies likelihood of the location of each landmark location. This heatmap is then converted into a location point (x, y coordinates) for each landmark as the final predicted location. To measure the model performance, Mean Square Error (MSE) between the actual landmark location and predicted location is used.
- **Programming interface**: *Python* as programming language and *Tensorflow with Keras* libraries for implementing CNN.

Results and Conclusions

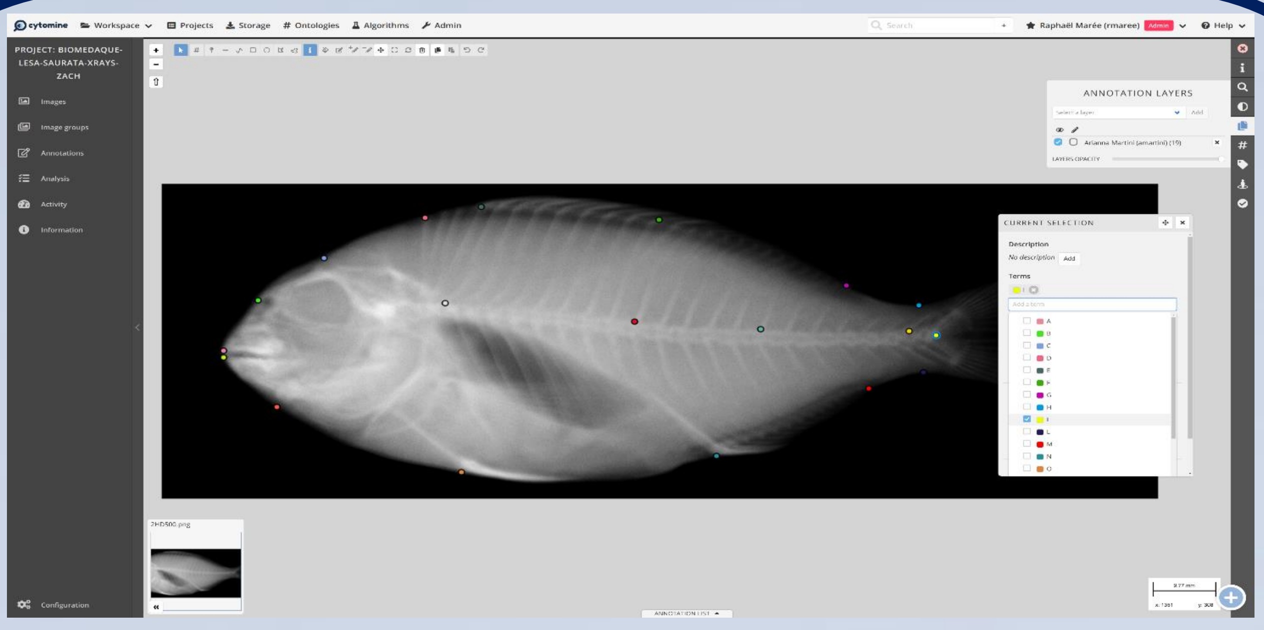
- The *test set* was used to measure the performance of the CNN model. We used Mean Square Error (MSE) as the metric for measuring the squared difference (in pixels) between actual landmarks locations and predicted locations. Sample predictions from the *test set* are shown below. Red dots represent the actual landmark positions and blue dots show the prediction from our model.





- The next steps will be to couple the external shape with the inner anatomy (i.e., skeletal quality) of each fish and classify them based on different anomalies typologies.
- This model could be used to assist researchers in the field of aquaculture to automatically perform morphometric analyses with less time and effort, as well as aid technicians during sorting processes, thus reducing manual labor and handling stress on the fish.
- Furthermore, we are going to extend this approach to post-larval and juvenile stages with different image modalities (RGB, microscopic, histological).
- Ultimately, the plan is to make the program available online as an interactive web interface in which farmers and researchers are able to upload images and receive quick and sound data regarding the prevalence and severity of skeleton deformity types among their stock.

Cytomine open-source web annotation tool



Overview of the Cytomine web image viewer and annotation tool for manual landmark annotation

Overview of manually annotated landmarks to train AI models

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