FishCam – A semi-automatic video-based monitoring system of fish migration

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Introduction

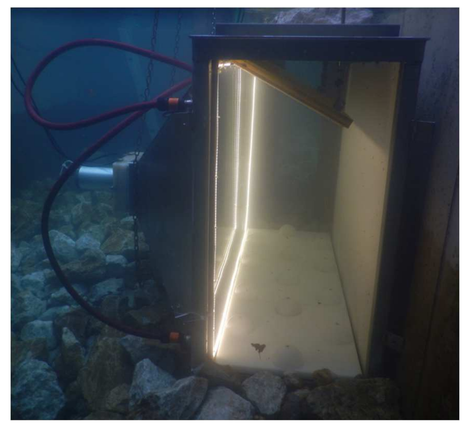
One of the main objectives of the EU Water Framework Directive is to preserve and restore the continuum of river networks for vertebrate migration. In this regard, fish ladders are a widely used measure. To reduce the monitoring cost and the stress for the fish of state-of-the-art monitoring methods (e.g. fish traps), we developed a video-based monitoring system, called FishCam. This system allows a continuous, all year round, contact-free monitoring of fish migration in fish ladders. One key challenge is the development of a software to automatize as much of the analysis as possible.

Left: A Danube Salmon (*Hucho Hucho*) caught in a typical fish-trap and pulled out of the water for monitoring purposes. **Right:** A 75cm Pike (*Esox lucius*) leaving the fish pass through the FishCam-System without any blocking.

FishCam – The hardware setup

During the project a detection tunnel was developed, that can be placed inside a common fish pass without any changes to the construction.

The tunnel is equipped with a high-resolution camera, which is connected to a motion sensor. Every time changes occur in the image a video is grabbed and stored for further processing. LED stripes where placed in the tunnel to enable constant light conditions throughout the whole day.



Underwater image of the detection tunnel

Some examples of different conditions the FishCam system is faced with.

FishNet – The monitoring software

As only around 3% of the grabbed videos contain actually any fish, one of the main tasks for the software is to robustly filter out these videos. The entire scope of functions an automatic monitoring software should ideally have are:

- Detect all fish
- Capture the migration direction
- Measure the Length
- Determine species

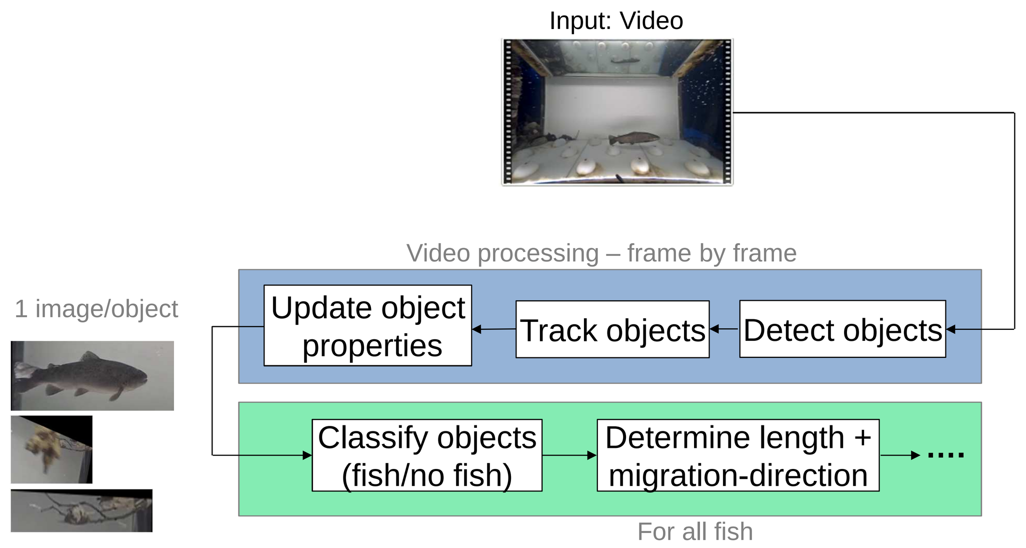
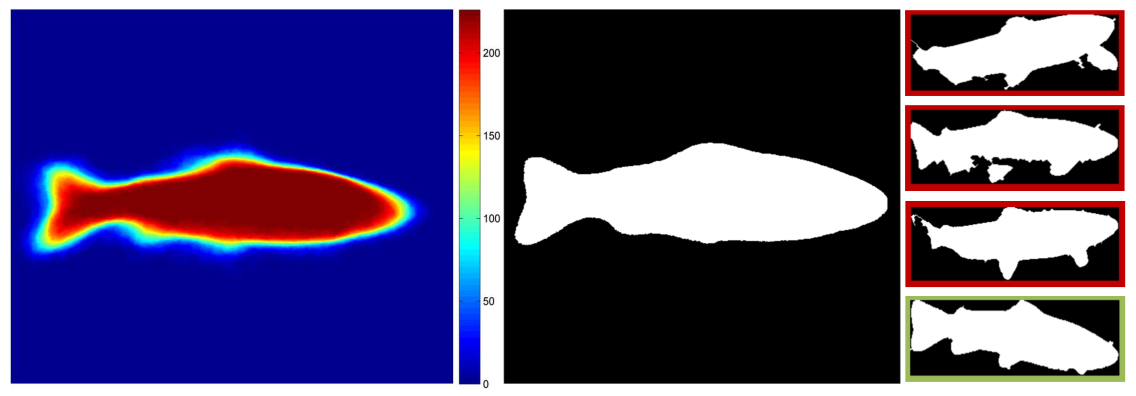


Figure above showing the flowchart of the already implemented functionality of the software

The first blob refers to video processing. Here moving objects are detected and tracked and for each object one single image is stored, the one that fits best the *fishmodel*. (See figure below)

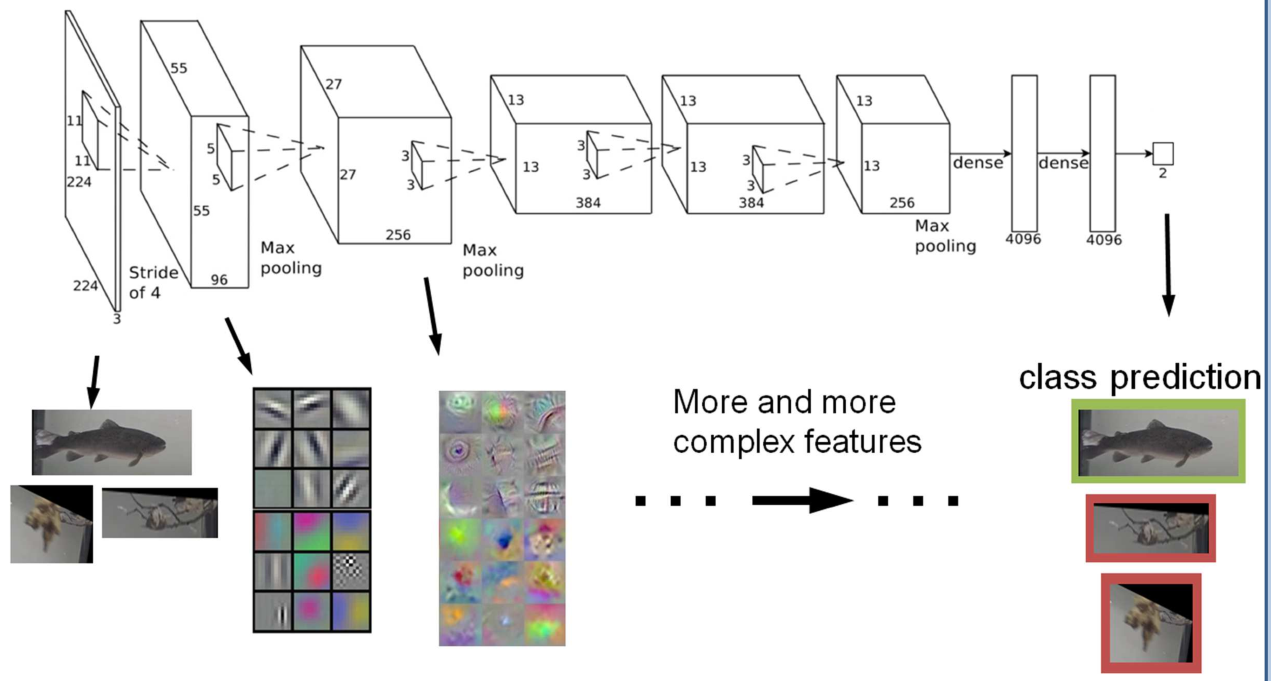


Left: Result of overlaying 225 black/white masks of native fish species. **Middle:** Generated *fishmodel* through thresholding by mean value. **Right:** Example of a selection made with the help of the *fishmodel* (rejected/selected). For the selected mask the corresponding RGB-Image is stored.

The idea behind the *fishmodel* is, that for classifying fish (as fish or in species) it is best to see it stretched out from the side. By comparing each object in each frame with the *fishmodel* we take care that the stored image per object fits this criterion best.

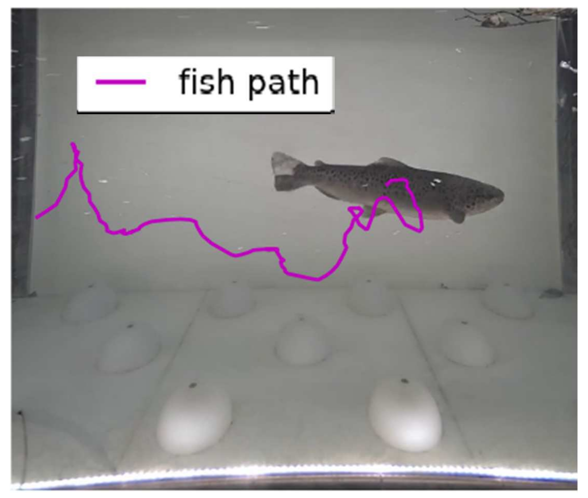
The second blob is the part of the post processing. This is, where all detected objects get classified into *fish* and *no fish* and the migration direction as well as the length get determined.

For the classification a pretrained and fine-tuned Deep Convolutional Network [1] is used. These state-of-the-art architectures recently surpassed human-level image classification accuracy [2]. The architecture of the used network is below.



The architecture of FishNet alongside some filter visualizations of [3]

Right: A mirror placed at the top enables spatial localization of the fish and allows the calculation of the real length.



Left: Though tracking of the fish throughout the video, the migration direction of each individual can be determined.

Results and Future Work

The FishNet-Classifier was fine-tuned on a basis of 38870 images (70/10/20 for training/validation/testing). The test set results are shown in the table below.

		Predicted Class		
		Fish	No-Fish	
True Class	Fish	3886	221	*Precision = 0.95*
	No-Fish	177	3490	*Neg. precision value = 0.95*
		Sensitivity = 0.96	*Specificity = 0.94*	*Accuracy = 0.95*

F1-Score = 0.96

The FishCam-System is/was already used in 14 fish passes over the last 2 years. Nearly one million videos had to be processed were only 3% contained actually any fish.

The **future steps** consist of finishing the automatization of fish length determination.
Two other open issues are the robust counting of fish in bigger schools as well as the automatization of the classification of the fish species.

Fish TV

If the QR-Code is not working, try this link: http://bit.ly/20HzQjD

References:
[1] A. Krizhevsky, I. Sutskever, GE Hinton. Imagenet classification with deep convolutional neural networks. *NIPS ,2012*
[2] K. He, X. Zhang, S. Ren and J. Sun. Delving deep into rectifiers: Surpassing human-level performance on imagenet classification. *ICCV, 2015*
[3] J. Yosinski, J. Clune, A. M. Nguyen, T. Fuchs, and H. Lipson. Understanding neural networks through deep visualization. *CoRR, vol. abs/1506.06579, 2015*

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