

Off-shore fish inspection with artificial intelligence

Pisces VMK (MI) manufactures fish processing equipment for on-board and off-shore facilities. Its customers are fleet performing year-around fishing expeditions in the Norwegian sea and Atlantic Ocean. Fishermen are interested in filling the boat as fast as possible with the highest quality of fishes and the least personnel since they share the income of the catch. Typically, fishes are brought on the boat and dropped into metal pockets which convey them through cleaning, cutting and filleting machines. Anomalies which must be detected at the beginning of the chain include fishes of the wrong species, damaged fishes, more than one fish in a pocket which will cause a jam of the filleting machine, and the improper positioning of a fish before entering the cutting machine. This type of inspection is not easy to deploy with conventional image processing tools since the size, shape and scales of fishes are difficult to model mathematically. Furthermore, their aspect can change depending on the location of the expedition and the season. Neural networks are known to offer solutions for such non-linear problems and General Vision has designed a CogniSight camera for Pisces based on a NeuroMem network and which can be trained on board by the fishermen themselves using a very simple and intuitive interface.



Additional important requirements for the CogniSight camera included a water-proof enclosure which can fit in a limited space above the conveyor and directly activate brushes which divert or reject the fishes depending on the result of the recognition. The system must run 24/7 throughout an expedition which can last 5-7 days. In case of a power down, the camera must automatically resume inspection each time it is powered back on. Finally, and most importantly, the inspection must be very easy to set-up, train and monitor for the fishermen.

In 2000, the above specifications immediately eliminated solutions based on the old-fashioned combination of camera, frame grabber and PC. The sole selection retained by Pisces was the ZICAM camera manufactured by Pulnix (now JAI) and featuring a General Vision CogniSight image recognition engine with a NeuroMem network of 312 neurons. Today, Pisces has installed over 30 CogniSight cameras and the fishermen love it because of its reliability, flexibility and ease of use. Their benefits are shorter expeditions, higher quality catch and revenues shared by lesser fishermen.

Installation and operation

Pisces is the manufacturer of the complete fileting line and installs them on boats. The inspection system is an add-on to their equipment and its installation is made quickly. The CogniSight camera and a strobe light are mounted above the conveyor just before the fileting machine and in a water-proof enclosure.

Although the camera is designed to run autonomously, it must be connected to the boat's local area network for three operations: (1) Sensor setup to ensure that the image is focused and well contrasted, (2) Initial training of the CogniSight recognition engine, (3) Access to reports with statistics on the number of acceptable and non-acceptable fishes. Usually, the sensor setup occurs at the time of installation and at the beginning of each new expedition. The training operation shall occur at the beginning of each new expedition and can be done by teaching examples as soon as the first fishes are caught, or by loading of a pre-existing knowledge file inspecting the same species of fishes.

As soon as a knowledge is loaded into the neurons of the camera, the latter starts recognizing fishes autonomously, activating one of its output lines to indicate if the content of the pocket is an Accept, Reject, Recycle or Empty. This signal is sent to the PLC which itself controls two brushes sending the fishes in a reject or recycle bin when applicable. The PLC is also interfaced to a magnetic sensor which detects each time a new pocket passes in front of the camera and generates the input trigger for the strobe light and image acquisition.

Training

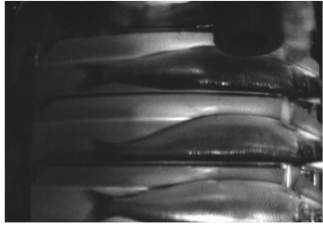
The autonomy of the recognition process relies on the CogniSight engine running on the camera. This engine consists of a NeuroMem network capable of learning by examples and generating models automatically. It can then recognize patterns which are identical or similar to the models stored in its neurons and produce a global response depending on the number of firing neurons and their level confidence.

Training sessions are made through a very simple Control Panel designed by General Vision. The application displays each triggered image capture and you can decide at any time to freeze its display and annotate the content of the pocket as Accept, Reject, Recycle or Empty. An Accept is a pocket showing a fish of the right species (herring for example) which is not damaged and in the proper position to enter the filleting machine. A Recycle is a pocket showing one fish of the right species which is not damaged but improperly oriented and cannot be cut as is. A Recycle

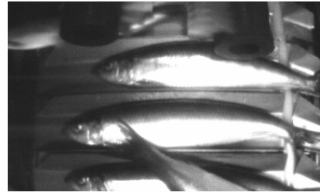
can also be a pocket with more than one fish of the correct species. The Recycle category is to divert the fish to a vibrating table so it can come back in a new pocket hopefully this time as a single sample and with a proper orientation. A Reject is a fish of the right species but damaged, or a fish of the wrong species.

Why is this fish acceptable?

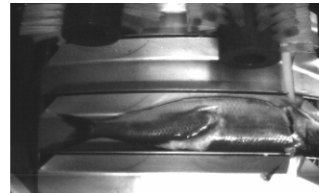
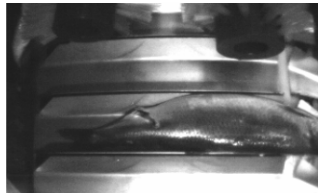
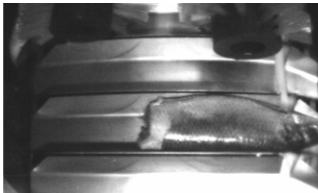
Right specie for the present expedition and
Acceptable size for the season and
Non damaged scale and
Proper orientation in the tray for the feeder



**If all is fine except orientation,
then Recycle**



Reject everything else...



The fishermen do not have to worry about describing these rules, they simply must click at one of the four buttons (Accept, Recycle, Reject or Empty) to teach the CogniSight engine. Actually, they are the ones who added the Empty category because they did not want to hear the relay of an ejection when a pocket is empty. The fishermen can easily validate the recognition accuracy by requesting the display or recording of one or several specific categories at a time. For example, if they check the Accept category on the monitoring panel, the camera will only transmit images of acceptable fishes. The operator can look at the screen focusing on the verification that no Reject or Recycle appears. To verify the detection of cases which occur seldom, such as Recycle, the selective image transmission can be converted into selective image recording. The operator does not have to stay in front of the screen and can review the results later. The observation of misclassification means that the CogniSight engine needs more training to either add new models to its knowledge base, or to correct neurons which overgeneralize to easily. This additional or corrective training can be made at any time on the filleting line, or later by using the recorded images and the General Vision Image Knowledge Builder application.

The knowledge

Remote training using the Image Knowledge Builder (IKB) application is easier and more reliable since the application allows batch training on images collected with the camera and pre-sorted into category folders (Accept, Recycle,

Eject, Empty). Also, if the camera is disconnected from the PC, IKB switches automatically to a mode where it will simulate the neurons instead of interfacing to the digital neurons of the camera.

Validation of the accuracy can be done in a few mouse clicks and verified on thousands of images if needed. Once accuracy is satisfactory, the contents of the neurons which describes their knowledge can be saved to an Image Knowledge File (IKF). This file can be used to initialize or update the knowledge of all the CogniSight cameras installed on the boat, but also on other boats running the same type of expeditions. Presently Pisces delivers the system with pre-defined Image Knowledge Files for fishing expeditions for herrings and mackerels. These files have been built over multiple expeditions occurring at different seasons and in various locations. The knowledge for the herrings is composed of less than a hundred neurons and has already inspected several millions of herrings.

The results

Pisces has presently installed over 30 systems on 5 different fleets in Norway, Iceland, Scotland and Denmark. So far, most expeditions have been for herrings and mackerels. Some fleets have expressed interest to add the inspection systems on fileting lines for sardines. The camera inspects at a speed of 360 pockets per minutes which is equivalent to 6 fishes per second. 98% accuracy was obtained for the classification of 16 tons of fishes with a knowledge based on 80 neurons. The inspection is a tedious job for a human operator, especially considering that he also must supervise multiple heavy and noisy machinery. Also, the use of the CogniSight cameras has contributed to shortening the duration of the expeditions.

For more information

General Vision, www.general-vision.com

Pisces VMK, www.pisces-ind.com