Towards the ecological dredger

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Abstract – *The dredging is a process that intrinsically damages the aquatic environment. Suctioning part of the aquatic bottom surface suppose not only change the ecosystem but it endanger the life of the animal and plant species. Nowadays, there is doing a lot of efforts to improve the ecological aspect of the dredging process. In this work, we propose the introduction of machine vision techniques to obtain this improvement, using hyperspectral imaging. The performed tests show that it is possible to reduce the environmental impact applying these techniques in two points of the dredging process.*

Keywords – *Dredging, computer vision, hyperspectral imaging, ecological dredger*

1. DREDGING PROCESS

The dredging work refers to removing mud or residues from the aquatic bottom, extracting them and disposing at a different location. This operation can be done in different places, as in the rivers, seas or ports, and targeting different objectives. Some examples of those objectives are the construction of new waterways, the improvement and cleaning of old waterways or the refilling of different kind of areas (harbors, artificial islands …).

In order to perform this job, different types of dredger are available. The *suction dredger* uses several tubes in order to extract the residues from the bottom, absorbing them. Another type is the *bucket dredger*. This one has an unlimited line of buckets which pick-up the residues from the water and place them in the dredger. Other types of dredger are the *grab dredger* and the *backhoe dredger*, which work like the bucket dredger.

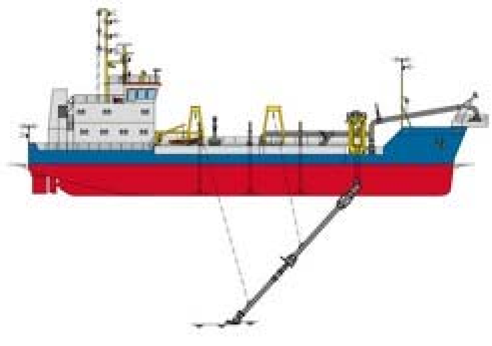

Fig. 1 Trailing Suction Hopper Dredger

In general, the suction dredgers are very common, and inside this group, the widely used dredger [1] is the *Trailing Suction Hopper Dredger* (TSHD). The dredging process of this kind of dredger is quite simple. The dredger diggs up the bottom using pressurized water. Then, it uses suction tubes in order to extract the material from the bottom of the water, and those tubes transports the suctioned material to the vessel.

It is possible to see that this process can hurt the underwater environment, so this work proposes several improvements on the TSHD in order to achieve a sustainable dredger.

2. ECOLOGICAL ASPECTS

Usually the dredging work is perceived as a non-ecological process which damages the aquatic life [2]. This is thought because the aquatic bottom material extraction is done in a very aggressive way. Frequently, the dredging zone contains contaminant materials which are digged up without a full control over the action. In this scenario, the water currents can move material to less contaminated places affecting directly to the aquatic ecosystem.

Nowadays, environmental studies are the main way in order to minimize the ecological damages [3]. These studies provide a chemical characterization of the materials, but this characterization is only obtained after a laboratory analysis. This method is focused in the previous state of the water bottom, so the analysis data is not available at the very moment of the digging and suctioning tasks. In that moment, is also important to have real-time information about what is happening with the contaminated material in order to reduce the impact in the environment.

There are other approaches that try to improve the environmental aspect of the dredging process. The efficient design of the suction drag head is one example, but there are some other points that can be improved: suction drag head efficient positioning or identification of the elements which exist over the bottom of the water (such as animals).

3. OUR CONTRIBUTION

Our work is centered on improve the ecological aspect of the dredging, applying new machine vision techniques. To this aim. we are working on hyperspectral imaging in the dredging process. The performed research is mainly focused on two parts of the whole process: the suction drag head and the hopper tank.

In the drag head, we propose the use of hyperspectral imaging in the 400 nm - 900 nm wavelength range which is the appropriate range to be used for underwater measurements as the absorption coefficient of the water gets its lower value at 400 nm.

From the captured images we performed a first basic processing selecting the three most discriminative bands from the whole spectra in order to be able to properly distinguish among the different materials. In the laboratory tests performed with this basic approach, we could difference between three elements which were underwater: the test aquatic floor, a metal piece and some organic elements (underwater plant). There is a clear usage of this advance: It will be possible to determine if in the dredging zone exist some metallic element (like an anchor) which could damage the dredger or if it exist some special water plant species and be capable to avoid an ecological damage.

The second kind of research was focused in the dredged mud which is in the hopper. In this place, we have tested the possibility of including a hyperspectral camera sensitive in the near infrared range (NIR), exactly between the 900 nm and 2500 nm wavelength. This range provides great amount information about the chemical composition of the materials. Unhopefully, the absorption properties of the water prevents for the use of this range bands inside the water. Because of this, we propose the use of these bands outside the water.

In this case, we achieved optimistic results. We can distinguish between different kind of muds by the means of their different concentrations of contaminant elements (zinc, cadmium, mercury and lead).

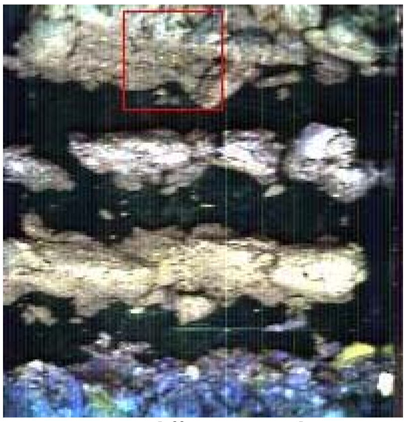

Fig. 2 Four different test mud types

The tests we performed consist of finding the separability between four different mud samples. With this target, we created a model [4] in order to distinguish those four classes.

For this purpose, a sample of each class of mud is obtained and processed spectrally and spatially. From this processing, a characteristic vector is extracted from each sample. This vector contains spectral information (which characterizes the chemical information of the sample), as well as spatial information. Spatially, the mud is composed with various elements like small stones, shells or sand. This fact means that each pixel of the mud hyperspectral image have a different chemical composition. Thanks to the spatial processing, we can generalize the information of a determinate mud, so its characteristic vector is going to identify the mud better than if it only had taken into account spectral information. The next step is the feeding of a specific Gaussian classifier with this characteristic vectors. Finally, this trained classifier was able to distinguish between the first four muds.

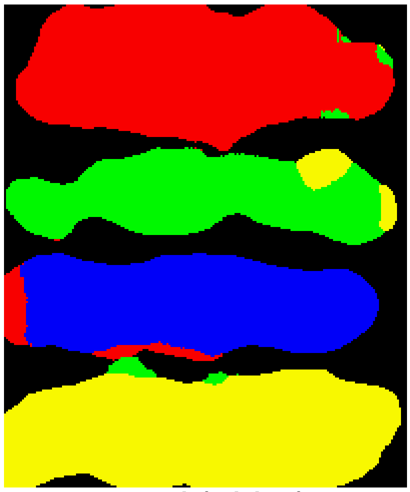

Fig. 3 Test muds final classification

This advance has a clear application in an ecological dredger. During the dredging process, is possible to detect the kind of mud that is being suctioned and actuate consequently. For example, if the dredger is suctioning a kind of mud with a high concentration of contaminant elements, those elements could be dispersed along the whole marine environment. So, in this case, the objective will be to reduce the pressure of the suction in order to decrease the environmental contamination, and have an accurate control on the suctioning process.

4. CONCLUSIONS AND FUTURE WORK

Nowadays, there are some improvements in order to reduce the environmental impact of the dredging process. In this work, we had presented a novel technique that identifies the kind of material that is being dredged so if it is contaminant is possible to handle it carefully.

We have proposed the introduction of the hyperspectral cameras in two key points of the dredging chain. The performed laboratory tests show us that, in the suction drag head, we can detect the kind of the ecosystem that exist in the aquatic bottom and avoid damage it. These tests also show that using hyperspectral imaging in the hopper tank, we can detect if the suctioned mud is contaminant and actuate in consequence.

As we saw, hyperspectral imaging applied to the dredging work is an effective way to improve the ecological aspect of the process in a trailing suction hopper dredger.

Future work is focused on test the algorithms in real-time in a real scenario, and on improve the classification algorithm, in order to achieve higher classification ratios.

5. ACKNOLEDGEMENTS

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