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SURVEILLING THE ECOLOGICAL VULNERABILITY OF FLOWING WATER UNDER THE EFFECTS OF FLOATING DEBRIS POLUTION

DOHI-TREPSZKER Gheza-Gavril[1], BADALUTA Minda Codruta[2], CRETU Gheorghe[3], TOMA Ioan Corneliu[4], DOHI-TREPSZKER Gergo[5]

Abstract

Abstract: Crisis demands the change of the „well proven" 'GREED' model to something new. It's never a good idea to waste resources, one must find value where yesterday one had had thought there was only garbage. This paper focuses on the ecological vulnerability of rivers, to accentuate the possibilities of relying on surveillance - video analytics. Using the capabilities of a semi supervised machine, which learns a counting method for floating Pet Bottles, based on pattern recognition a new type of surveillance technique is proposed. The solution reduces costs, the required number of employees, by several orders of magnitude, and increases productivity.

Keywords: "polluter pays" principle, data mining, artificial intelligence, floater, river debris, ecological vulnerability.

1. INTRODUCTION

Planting a surveillance system on river banks preserves valuables (clean water, hydro-technical assets) deterring and helping the identification of the polluter for further action, lowers litigation costs and mitigates the risks of all of the above. These ideas are good on a conceptual level, but also arise issues such as finding ways to, transmit data, possibilities of storage and finding ways to use (mine) the incredibly vast, generated database. After the analysis of enumerated success criteria, only the events of interest must be processed, the rest may be discarded. For deterring the polluters or identifying pollutants, video analytics offer a feasible solution.

There are many methods for monitoring water pollution with liquids or solvable solids: gravimetric; volumetric; optical; electrical; separation; thermal; resonance. They are found in the form of standards, (hundreds) [1],[2],[3],[4]. For pollution with unsolvable solids the uniquely used method is visual inspection, to which the presence of a person is compulsory. The human resource factor presents the highest cost of any working business. In the last four decades video surveillance pervaded the public places for the purpose of observation, successfully replacing humans, easing their work particularly after video analytics proved new capabilities in traffic, dwell and perimeter protection, left luggage identification, gesture recognition etc. The question arises why not implement this technology in ecology? In this paper, a method is proposed which uses the semi-supervised capabilities of machines, in a specific way, to recognize specific patterns, floating pollutants in general and Pet Bottles specifically.

2. PET BOTTLE LIFE CYCLE, SPECIFICS, AND FUTURE

PET was patented in 1949 [5] and the first shape of the PET Bottle in 1973 [6] and the past four decades gave the ubiquitous packaging material infinite number of sizes, shapes and colors. Where are these PET BOTTLES now? Luckily a small percentage was recycled, but the rest contribute to environmental pollution; constituting "fish food" [7],[8], "bird food", "artificial colors for water (their content) ", risk factor for energy security (clogging hydraulic turbines from the hydro unit) [11], "artificial decorations for water sports place". (Figure 1 – 5).

Figure 1 - The fish food

[1] Faculty of Civil Engineering, Departament of Hydrotehnica, George Enescu Street No. 1/A, 300022, Timişoara,
e-mail: badaluta_ minda @yahoo.com

Figure 2 – The bird food

Figure 3 - The artificial colors for water

Figure 4 – The water pollution

Figure 5 – The artificial decorations for water sports place

The European Union has given several directives, the last is [14], which has the goal to increase the level of plastic recycling and to reduce the threat of pollution, but according to the official statistics, the change has not reached the point of inflection.

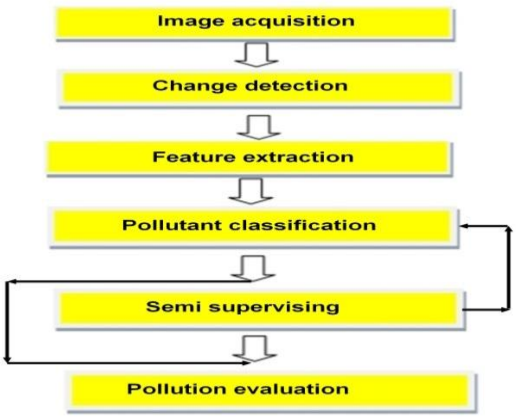
3. POLLUTANT SEGMENTATION

Reaching water, the shape and the size of plastic material (figure 6) is modified due to mechanical interactions. The color changes due to the effects of sun/shade which greatly hinder recognition based on pixel or template match and bring up the need to do feature based recognition.

Figure 6 - The shape and the size of plastic material

The very old desire to see something, better, more detailed, more closely is just as valid today as it used to be.

Background subtraction is one of the first change detection techniques used in video analytics with great success.



The flowing river and the neighboring vegetation are called dynamic background and needs an advanced technique to recognize their pattern which can cope with their changing habits.

Applying four dedicated methods for difficult background subtraction cases, the best result of the experiment is related in detail in.

4. VIDEO ANALITYCS FOR PET BOTTLE DETECTION

Shape, size and color are good features to observe and great characteristics for describing an object (in this case PET BOTTLES) [15].

If grouped, these describing characteristics would result the following families: Shape and size (geometrical), Appearance (color, brightness), Pass/does not pass, Statistical.

To distinguish pollutant floaters from other types of existing floaters on the water surface, such as driftwood, and to count them to obtain a possibility for the application of a numerical approach, regarding the state of the water, mainly two intuitive attributes are used, which are simple to compute, namely area/perimeter ratio and minimum/maximum ratio.

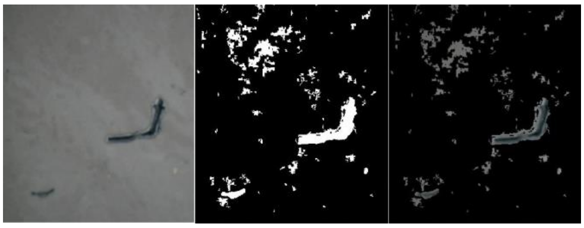


Figure 7 - The driftwood

Minimum and maximum gray values within the region of interest.

In order to be useful for classification, an attribute must have a low variability within a class, and must show a large variation between classes.

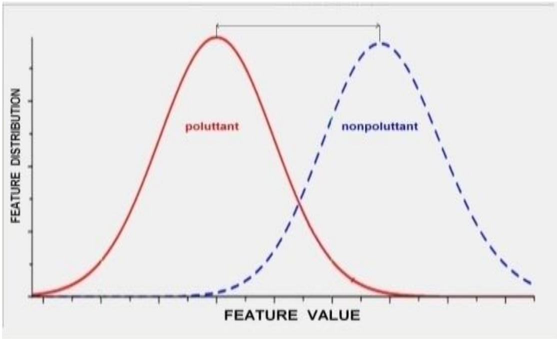


Figure 8 - The classification of attributes

In [17] a detailed description of the method that is used to define and select features is explained. It is shown that obtaining finally a peak performance, one very close to the human capabilities [18] is possible.

The most useful features have been found to be the ones defined bellow. The first one is circularity, defined as:

$$\text{Circularity}= 4\pi \cdot \frac{Area}{Perimeter^2} \quad (1),$$

Where *Area* is the number of pixels of a detected blob and *Perimeter* is the number of pixels of its borders.

The more elongated is the shape the closer to 0 is the parameter value, while the maximum value of 1 is obtained for a perfectly circular shape.

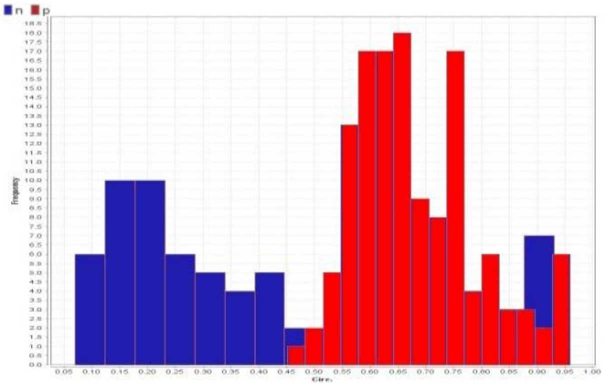


Figure 9 – The circularity depending on the frequency

The second selected feature is the standard deviation of the gray levels inside the object blob:

$$\text{StDev} = \sqrt{\frac{\sum_{i=1}^{k}\left(x_i - \overline{x}\right)^2 n_i}{\sum_{i=1}^{k} n_i}} \quad (2)$$

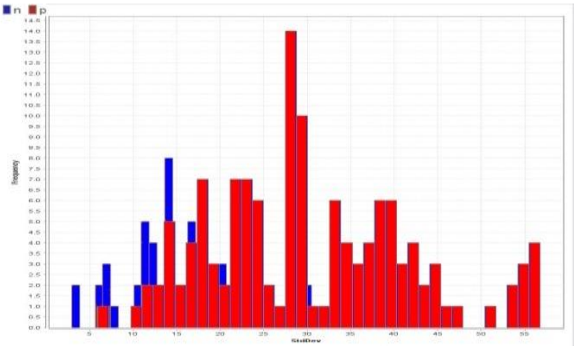


Figure 10 – The standard deviation depending on the frequency

The last feature selected is solidity, defined as:

$$\text{Solidity}= \frac{Area}{ConvexArea} \quad (3)$$

Where: Convex Area represents the convex hull (minimum area convex polygon) containing the object.

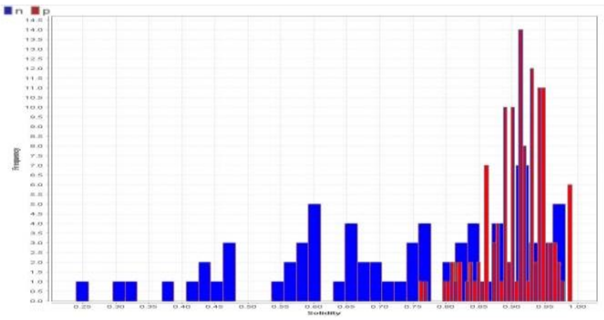
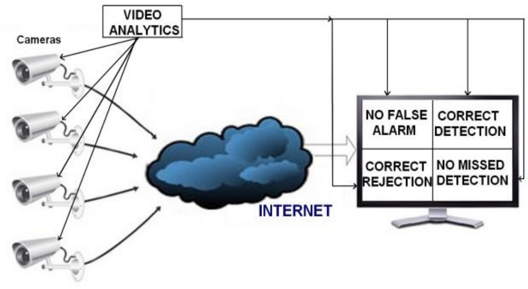


Figure 11 – The solidity depending on the frequency

5. RELATED WORK, RESULTS AND CONCLUSION.

The several hundreds of hours of movies used for this study have been recorded in a period of six years on the Somes river and its tributaries Tur, Valea Rea, Valea Alba, but also on the river Bega, usually on car and railway bridge tops, allowing good visibility and perspective, generally during periods of high water levels, but also in normal flowing conditions.

Using heuristic methods focused on maximizing the accuracy and minimizing false alarms with a subset of features -Circularity, Standard Deviation, Solidity- arriving at an accuracy of 93.5% which approaches the human limit [16] and combined with another subset -Circularity, B, BY (Bounding Rectangle) an accuracy of 94.5% was reached.



After recognition the next step is counting, coupled with parameter definition. Using the six criteria by Maher and Cullen (1997) provided to define a relevant parameter regarding water quality [21] and knowing the used parameter for visual inspection **counted PB/min** the suggestion is to:

- **PB/m^2** in a reference section
- **PB/s** in a reference section -the difference between the two is significant; **PB/m^2** gives information on the degree of pollution **PB/s** besides pollution degree provides information on the speed of propagation.

$$C_{PB/mp} = \frac{\text{Area Covered with PB}}{\text{Surveilled Area}}$$

All PB area, or
PB covered area

Flow velocity and derivatives can also be computed with Video Analytics since 1980 [20]. The proposed surveillance system is able to create a database of specific floating pollution - initially only specific for PB, but with the possibility of extension for driftwood, dead fish, oil spills, etc.

Those parameters can be stored in time series, and constitute a record of pollution about non solvable solids.

Combined with drones, equipped with cameras which can track and record the pollution wave propagation valuable information can be brought about the evolution in the time of the event.

Thresholds could also be defined: normal, alert etc., similar to those used against floods, for different states of alert in case of extreme events of pollution.

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