Retraction

Retraction: Analysis and Classification of Active Sludge in wastewater (J. Phys.: Conf. Ser. 1916 012016)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Analysis and Classification of Active Sludge in wastewater

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Abstract. Active Sludge particles in wastewater or sewage water treatment plants are analyzed. Based on the analysis report, the water is treated to improve the quality of water so that it can be reused. Microscopic images of water samples are obtained from municipal Active Sludge wastewater treatment plants for analysis, so that particles can be viewed clearly. A method that exactly determines the length of filamentous bacteria and flocs segmented from the images is proposed in this paper. Texture and shape features are extracted from the filaments and flocs. An SVM classifier is used to classify the flocs and filaments using the features extracted. Based on the distribution of sludge particles in a particular area, Artificial intelligence is used to find the process of chemical treatment. This helps in treatment of wastewater for further reuse.

1. Introduction
Active Sludge has fibers and flocs. Fibers and Flocs cover the surface of contaminated water. This is a mixture of microbes, organic matter, and dead cells. Balance between different types of wireless bacteria is important. Fibers are defined in two ways in which one is a long particle common in liquid layers or a sample with different characteristics in flocs. It is also described as a collection of large algae flocs, so that their features and texture are similar to those of flocs. Fibers can be separated from the flocs by their continuous nature, and the flocs do not bind, as each microorganism has its own characteristics. But in rare cases, the fibers are made up of interlocking flocs. Analysis of sewage or contaminated water is done prior to the cleaning process. Sewage or contaminated water around us is targeted to identify these particles by specific emissions. A clear report of flocs and filaments and size distribution is required for effective control [1]. A few methods are described in detail in the diagnostic literature and analysis of flocs and fibers. Each method has a unique method for processing and analyzing sewage or wastewater from treatment plant samples. In the same way, the size of the size parameter or the distribution of the exact size is calculated to determine the size of the flocs and strands. Factors are extracted from events by adding a few chemicals to the sample, where the texture of the fibers can be damaged [2]. Alternatively, fibers and flocs are found in wastewater using LabView without adding any chemicals to the samples [3]. Alternatively, the fibers are separated from the flocs by their structure, using image processing. To obtain a detailed structure of flocs and filaments, classification is applied to smaller images where the old image sample methods are measured before the procedure. Location and other parameters are removed to separate the flocs from the fibers [4]. Tiny images of activated mud are processed, followed by the process of thread recognition and the length measurement of the threads which is why
the length of the thread is updated. However, all methods are not suitable for all areas, most of which use chemicals to better monitor germs. Therefore, Activated Sludge analysis using Image processing is available faster and is the most effective way to obtain reports on a sample of wastewater or sewage. The process of purification of Active Sludge wastewater varies and is tested elsewhere [5-9].

2. Methodology
The paper is based on Active Sludge wastewater monitoring and analysis with Image processing which have been surveyed with the existing process and models to ensure this procedure as the enhanced and accurate process [10]. The sewage or wastewater analysis is done in two steps. The first step is to acquire the sample and next is to process the sample. A total of 36 samples of microscopic images from the Activated Sludge wastewater treatment plant are acquired from the database. Once the images are processed, Contour Tracing Algorithm [11] is applied to draw lines for the continuous particles after diluting it, to get the features of the particles. Features namely Mean, Standard Deviation, Contrast, Correlation, Area, Perimeter, Centroid and Length are extracted from the sample image, once the edges of the particles are detected. The features aid to know about the nature of the filament and microorganisms present in the sample of the treatment plant [12].

2.1. Detection of Filaments and Flocs
Samples of microscopic images of wastewater are obtained from the Activated Sludge wastewater treatment plant. The images of both sludge and the normal bacteria are shown in Figure 1. Input images are converted to grayscale for further process as thresholding and many algorithms work well with grayscale images. The grayscale images of both sludge and the normal bacteria are shown in Figure 2.

Morphological top-bottom-hat filtering of the grayscale or binary input image is done to enhance edges. The filtered enhanced image having sludge and bacteria is shown in Figure 3. The grayscale image is converted to binary image, using Otsu threshold algorithm all pixels in the input image with luminance higher than a threshold level are replaced with value 1 (white) and all other pixels are replaced with value 0 (black). Figure 4 shows the binary image obtained following the process of Top-Bottom Hat filtering.

Phase congruency performs calculations on amplitude and phase of the individual frequency components in a signal. Features in an image such as curves or connected regions are points where Fourier components are maximally in phase. Filaments are continuous in nature. Phase congruency is used to segment the filamentous bacteria in the phase-contrast microscopic images of Activated
Sludge. Figure 5 shows particles in water highlighted after phase congruency is done. Figure 6 shows the binary image obtained after performing phase congruency.

Debris removal is the process of removing noise in an image. All connected components, having less than a certain number of pixels in the binary image are removed, the output of which is shown in Figure 7.

The filtered image is masked over the grayscale image. The resultant image is subtracted from the binary image to detect changes between the two images. The subtracted image is shown in Figure 8. This is the first stage of floc removal.

The image obtained by performing phase congruency is masked over the grayscale image, the resultant of which is called the Inter floc Holes Identified image. The image converted to binary after performing phase congruency is then added with Inter floc Holes Identified image to acquire the second set of difference, as shown in Figure 9. This is the second stage of floc removal.

The images obtained from stage 1 and stages 2 are fused to differentiate between filaments and flocs. In the fused image, objects with a radius of gyration less than a threshold are removed. This is done to remove the false filaments. The fused image is shown in Figure 10.

The image obtained after fusion in Figure 10 (False Filament removed) is subtracted from the Inter Floc Holes Identified image to get a clear view of the microscopic particles. The resultant image shown in Figure 11 is still corrupted by noise.

The image obtained after fusion in Figure 10 (False Filament removed) is fused with Inter Floc Holes Identified image to get a clear view of the microscopic particles and is shown in Figure 12.
3. Feature extraction and classification

The images shown below are the processed output image and its dilated version, from which features characteristic of filaments and holes are extracted. Figures 13(a) and Figures 13(b) show the processed image and its respective dilated version.

Two types of features namely Shape and Texture are extracted from filaments and flocs.

3.1. Shape Features

Shape features define the basic structure of the filaments and flocs. Shape features extracted are Area, Perimeter, Diameter, Density and Length. Area is defined as the pixel count inside a marked area of an image. Perimeter is defined as the pixel count along the edge of the marked region of an image. Diameter determines the number of circled pixel values in the same line.

Density: Number of pixels per inch (ppi) or pixels per centimeter (ppcm) and it is also known as the resolution of an image. The density of the filaments and flocs are extracted through Contour Algorithm and is shown in Figure 14.

**Length**: Pixels are arranged in a regular continuous manner with a starting and ending point. To get continuity of the filaments, g and h matrix values obtained from contour algorithm are plotted. Using these, four separate filaments obtained are shown in Figures 15, 16, 17 and 18. The four long filaments shown are for a length >1000 pixels & density level < 100.
Of a total of 2010 filaments in the sample image, 4 filaments with a length >1000 pixels & density level < 100 are detected and traced.

3.2. Texture Features
Texture features is the calculation with a set of metrics in an image to classify the perceived texture of an image. The features extracted from Standard Deviation, Grey level co-occurrence matrix (GLCM) are Mean, Contrast, Entropy, Correlation, Energy and Homogeneity. Contrast measures the intensity between a pixel and its neighbour over the whole image. Energy is defined as the uniformity of an image; it is the sum of squared elements in the GLCM. Correlation measures how a pixel is correlated to its neighbour over the whole image. Homogeneity is a parameter that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. Once the features are extracted, a support vector machine (SVM) is designed to detect filaments and flocs.

3.3. Classification using SVM
The features are extracted from a total of 36 image samples of wastewater. These are used to train and test the designed SVM for classification of filaments and flocs. The SVM classifier is trained with 36 samples where 18 samples for each filament and flocs respectively are taken. The performance of SVM classifier is tested with various kernel functions like: Linear– dot product, Quadratic– Quadratic processing, Polynomial– Polynomial processing with order of 3, RBF– Radial Basis Function with scaling factor sigma of 1, MLP– Multilayer Perceptron Function with scale of 1-1. Table 1 and Table 2 shows the individually classified sample images for filaments and flocs based on the kernel functions and Table 3 shows the overall accuracy rate.

The accuracy of SVM classifier varies for different kernel functions. It is found to be optimum for a linear kernel function. However, the classification accuracy of filaments is greater when compared to that of flocs.

| Table 1. Filaments comparison table |
|------------------------------------|
| **Type** | **No. of filaments classified** |

![Figure 15. Long Filament 1](image1)
![Figure 16. Long Filament 2](image2)
![Figure 17. Long Filament 3](image3)
![Figure 18. Long Filament 4](image4)
Table 2. Flocs comparison table

| Type                  | Function   | No. of flocs classified |
|-----------------------|------------|-------------------------|
|                       | linear     | quadratic | Polynomial | RBF | MLF |
| Correctly classified  | 16         | 18        | 18         | 17  | 11  |
| Total no of samples   | 18         | 18        | 18         | 18  | 18  |
| Accuracy of classification | 88.8% | 100%        | 100%        | 94.4% | 61.1% |

Table 3. Overall accuracy table for kernel functions

| Kernel Function | Filaments Accuracy % | Flocs Accuracy % | Overall Accuracy % |
|-----------------|----------------------|-----------------|--------------------|
| Linear          | 88.8                 | 77.7            | 83.25              |
| quadratic       | 100                  | 94.4            | 97.2               |
| polynomial      | 100                  | 100             | 100                |
| RBF             | 94.4                 | 94.4            | 94.4               |
| MLF             | 61.1                 | 55.5            | 58.3               |

4. Conclusion

The parameters of the parameters and characteristics from the wastewater treatment plant samples are successfully analyzed, especially the filament length, particle texture and shape characteristics. To avoid the impairment of previous methods, image processing will be the best and most effective method of analysis. The proposed separation classification algorithm has shown good results that speak for image class differences. Processing the image appears to be superior to other methods in the analysis of activated Sludge when compared to previous methods. The contour algorithm is useful for analyzing particle density and detecting particle continuity. The SVM separator was trained and tested with 18 samples in a row providing a separation accuracy of 88.8% of fibers and 77.7% of flocs.

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