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Title: Classification and counting system for bacteria in microbiological culture media using image processing

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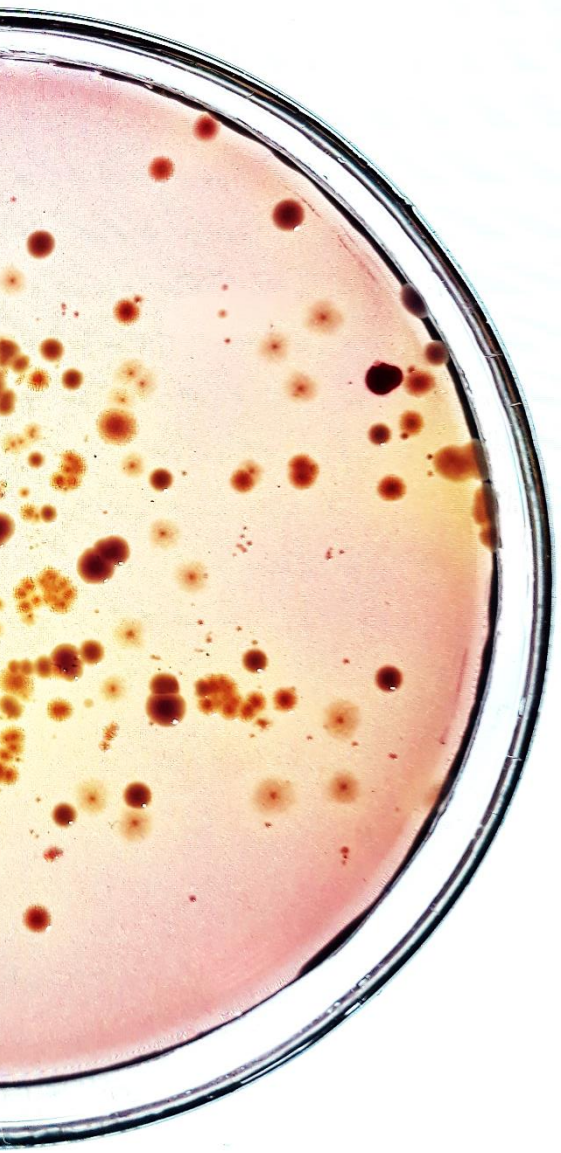

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Introduction

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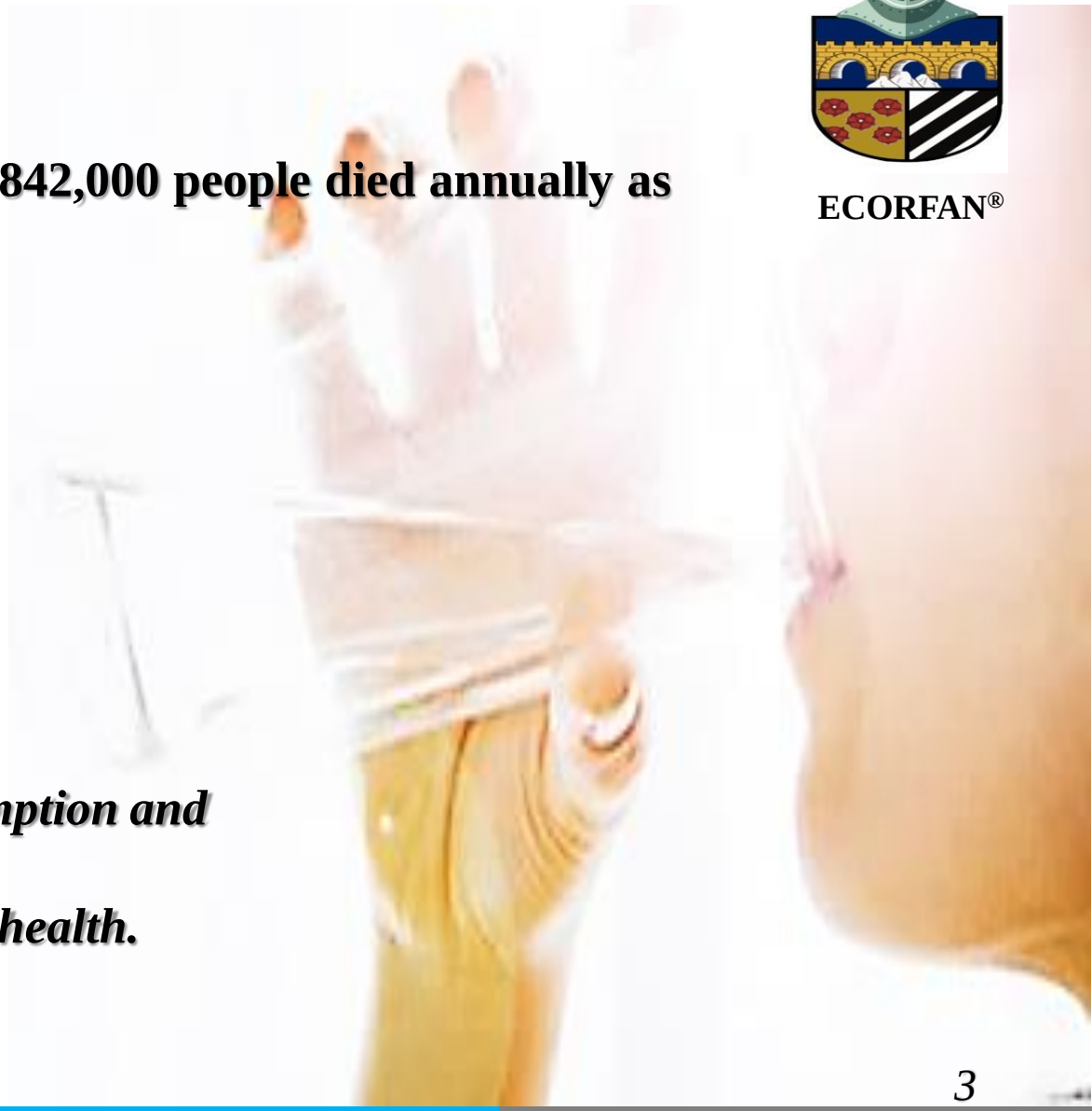
In 2019, the World Health Organization declared that 842,000 people died annually as a result of:

- ***unsafe water,***
- ***poor sanitation,***
- ***inappropriate hygiene during hand washing.***



The pandemic caused by Covid-19:

- ***availability of water source is essential for the consumption and hygiene of everyone.***
- ***Water represents an important vulnerability factor in health.***

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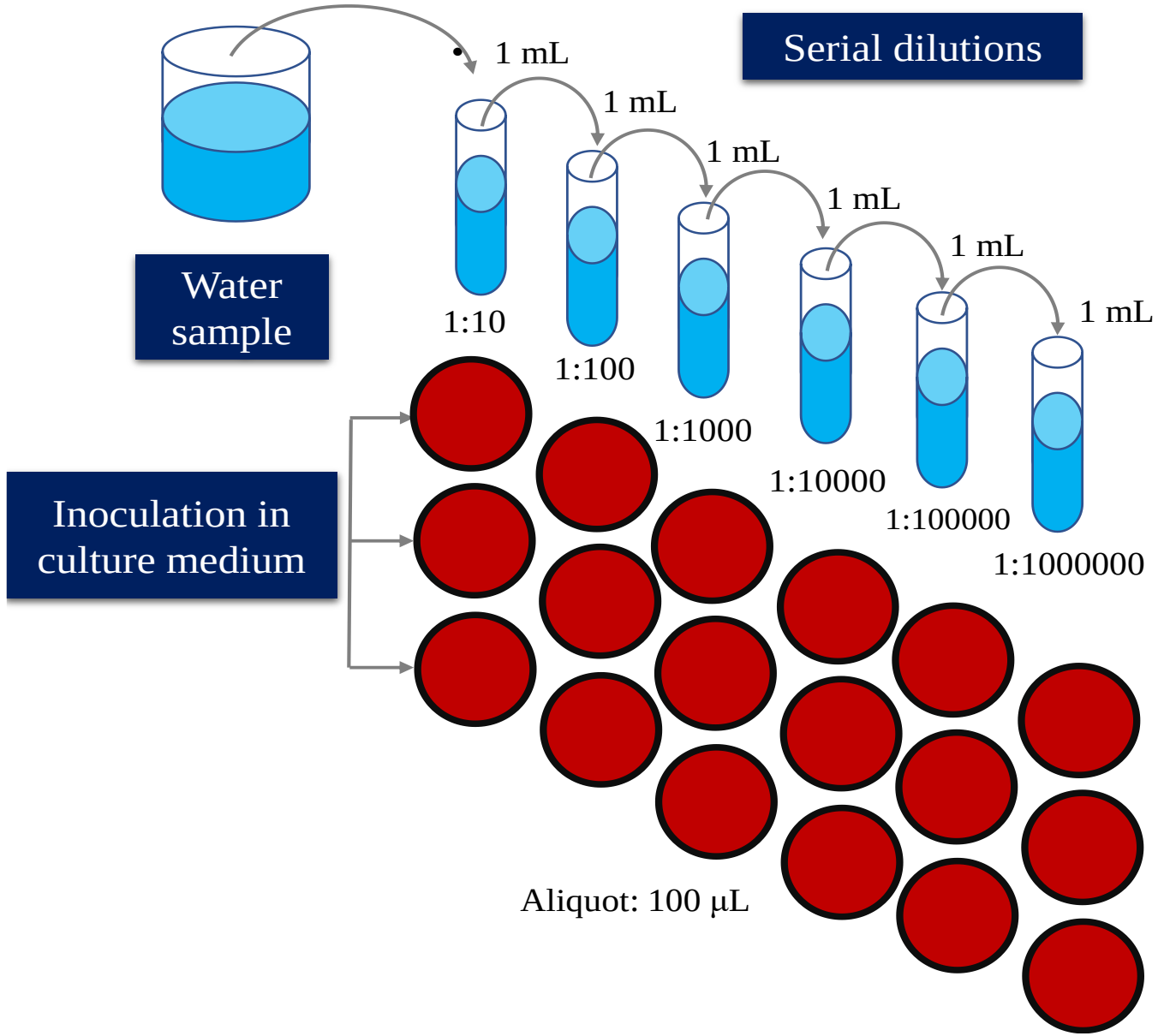
Microbiological monitoring

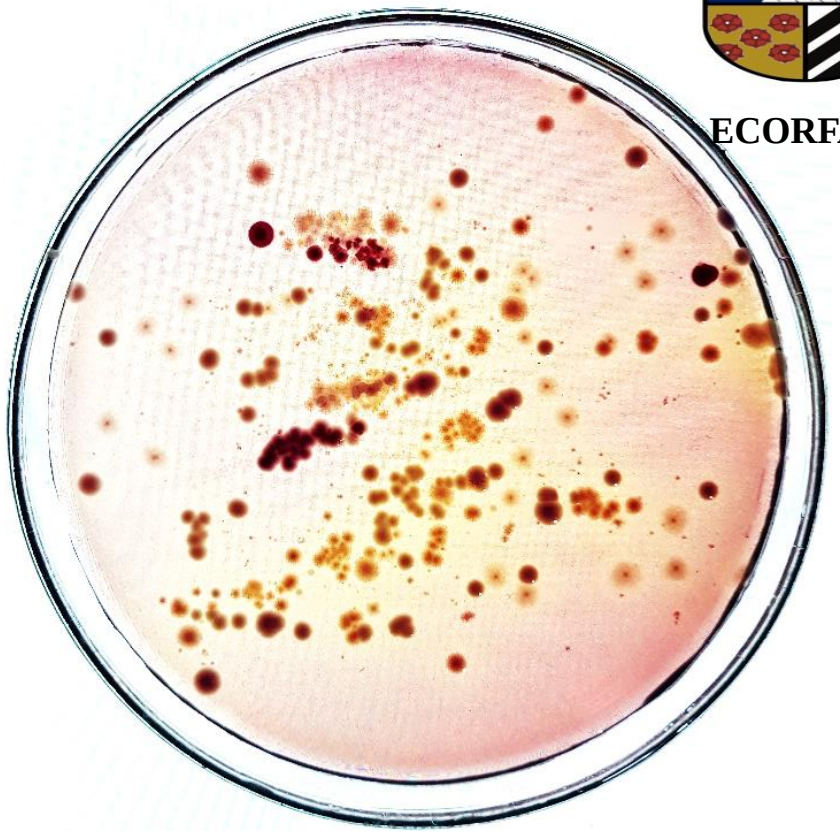
Water quality

Avoid a risk health for population

Melo-Florián (2015)

Daigle, 2016





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Implementation in plate count technique to a water sample

Identification and quantitative determination of bacteria in culture medium:

Medina, 2008

- ***Long periods of time.***
- ***High economic investment***

EMYR, 2021

- ***High cost.***
- ***Specialized maintenance.***
- ***Space under certain conditions.***
- ***Designed to operate only under stablished standards.***

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Stages for system development

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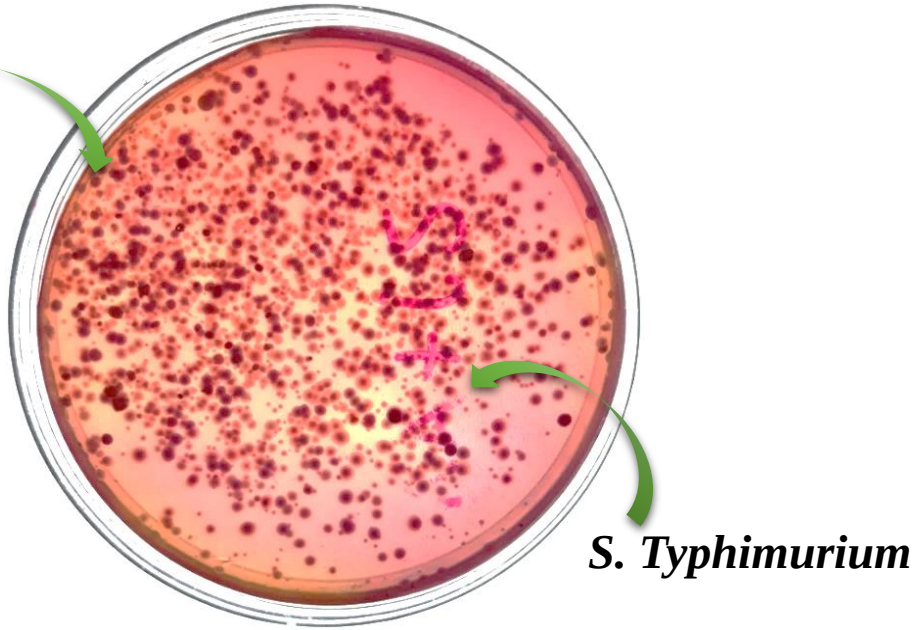
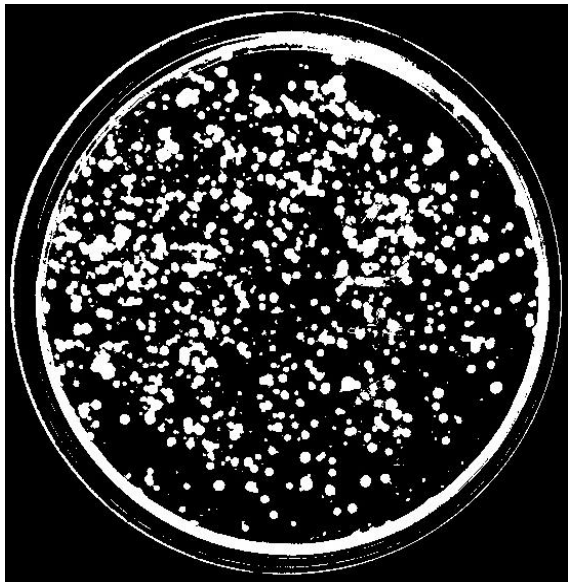
The first stage consists of testing a set of segmentation techniques to separate the bacterial colonies from the rest of the image sections that are not of interest:

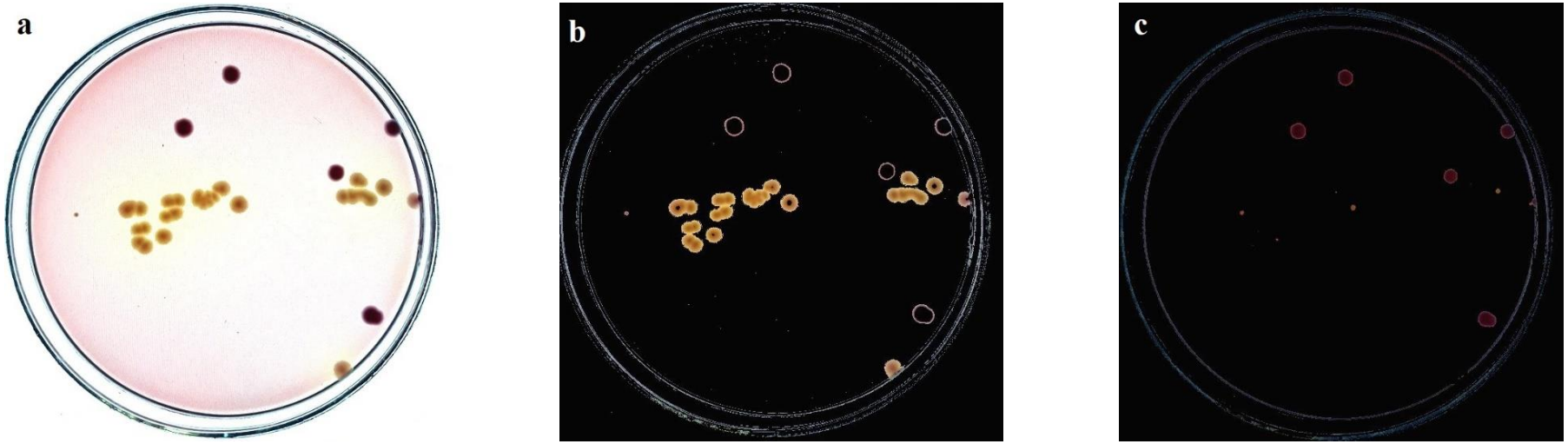
- *thresholding,*
- *edge extraction by Canny algorithm and*
- *clustering by K-means.*

Red Bile Violet agar





Segmentation produced by the thresholding algorithm applied to the culture.



Segmentation produced by the K-means algorithm.

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Automatic system for classifying and counting bacteria

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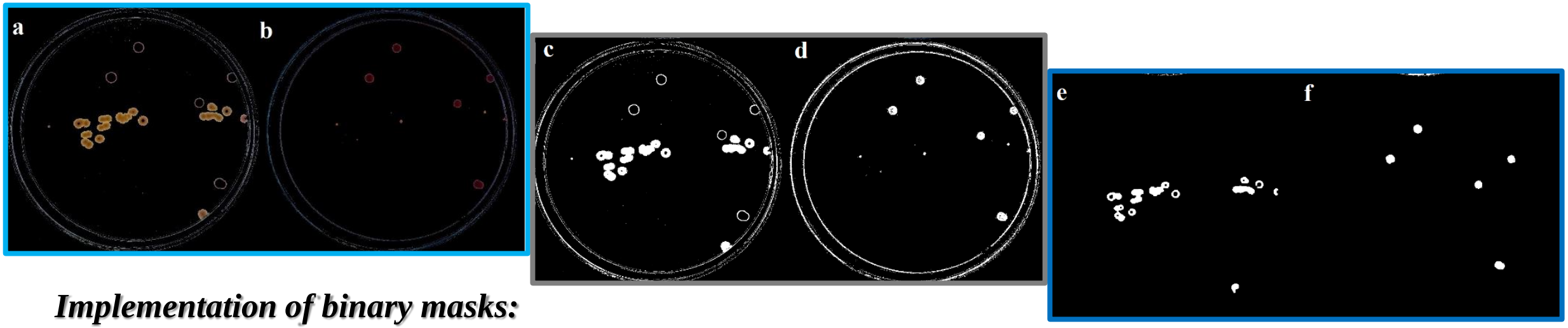
The second stage consists in the implementation of an automated bacterial colony detection and counting system that indicates in the original image the contour found for each of the colonies and, in turn, displays the final count of their number.

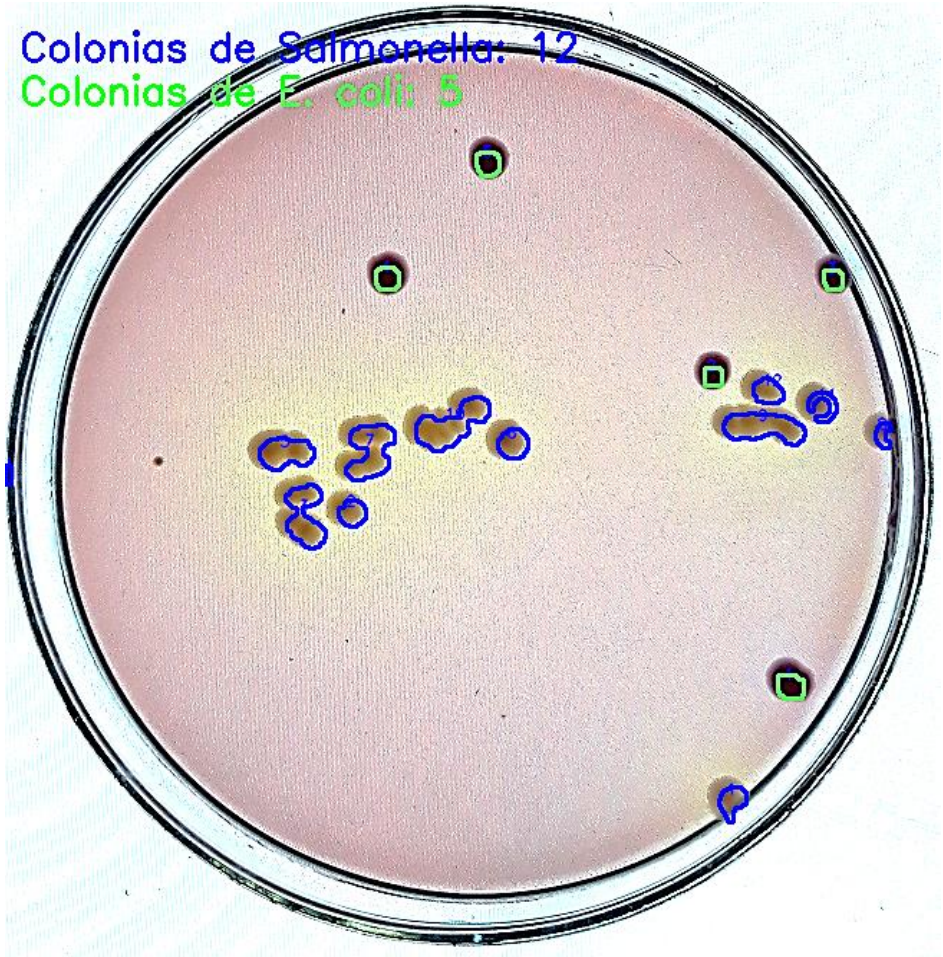


Implementation of binary masks:

a) and b) K-means results.

c) and d) thresholding.

e) and f) Application of morphological operations: erosion, dilation, opening and closing.



The culture image is submitted for analysis. The system draws an outline around each bacterial colony and distinguishes between two types of existing colonies, blue corresponding to E. coli and green to S. Typhimurium.

Conclusions

In this work, a classifier and counter of bacterial colonies in laboratory cultures was successfully performed by processing images obtained with a smartphone. The implementation of an unsupervised learning algorithm allowed, without prior training, to separate the bacterial colonies from the other elements of the image such as: the Petri dish, the agar, the background objects and the artifacts generated by the capture conditions. It was even possible to successfully segment the types of existing colonies, allowing their classification and counting by type.

The system was implemented using open source software, employs low-cost hardware and can be easily scaled for real-time operation through video analysis.

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