Identification of transition processes parameters in flotation machine by computer vision

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Abstract. The efficiency of potassium fertilizers production needs to improve industrial control systems because the fertilizers are very important for agriculture and economy all over the world. Now a control of flotation quality is made by a visual operator’s observation, and a human factor could influence on the results. This paper is about of researching of foam recognize algorithms based on determination of flares from bubble surfaces. Statistics of flares are used for determination of parameters of transition processes in the flotation machine. A method based on bubble flares detection instead of bubble borders recognition. The method allows recognizing bubbles even on a surface of specific potassium foam, non-contrast, solid and color. This research solves the tasks of an optimal binarization threshold approximation, foam driver imagination exclusion, transition process detection. The optimal threshold is developed from medium frame luminosity quite linear. The foam driver can be excluded from the frame by specific character of luminosity trend. The transition process leads to change of bubbles count easy detected by software. A time of processing is about 15-30 ms per frame. Thus, the method can be used as in alarm systems, so in control systems on decision support systems.

1. Introduction
Potassium fertilizers are very important to agriculture. They increase productivity, resistance against diseases and a growth velocity of plants. The production of potassium fertilizers is a valuable export deal for producing countries such as Canada or Russia. So increasing of production processes is an important and actual task. One of most valuable production stage is a flotation. A sludge flotation is used to split useful and insoluble ore components. A next stage is sylvine flotation when KCl and NaCl are split. Both processes are flowing with a foam layer creation. The foam must be smooth, must consist bubbles of equal determined size for maximum quality of KCl extraction. A productivity of the machine and a quality of the flotation is closely linked with foam parameters. But there are no devices for foam testing useful in potassium flotation conditions. A control of the foam parameters are made by human – an operator of a flotator. It is leads to human factor expressions such as mistakes, or errors, of delay in an operator’s reaction. The flotator is observing the foam visually time by time when he is going near the machine. A flotation plant can have many machines (for example, 20-30), so the operator can not observe all of them immediately. A view of the foam (color, organoleptic density, disturbances, smooth etc) is the information for decision support [1, 2, 3]. That is why a task of decreasing of human factor influence is very relevant as a part of production efficiency increasing.

One of possible ways is a computer vision systems using. Non-breakable observation could avoid
of delays in identification of transition processes. Computer vision systems are widely used in polymetal or coal flotation machines. The coal foam has a high contrast surface, but even here many computation problems are occurs. The foam in potassium flotation machines is non contrast, solid, with a wide range of bubbles size. It leads to difficulties in a bubbles borders detection, which is applied by most authors.

Some authors (for example [4]) suggested to design of three dimensional foam models for a high-quality definition of processes and reasonable decision support, but they met with computation complexity usually. Authors [5] have led to result about irresistible complexity of a video stream processing. One of conclusions in the paper is possibility of reconstruction algorithms can be used only for static pictures with a successful speed of processing. Many algorithms useable for coal flotation nearly in real time cannot be used for the potassium flotation because the coal foam is black and white, but the color of potassium foam and RGB relation are important to decision support.

The authors [6] have suggested a method of bubble clusters detection and small and big bubbles separately. But many methods are mostly ideas then real using in enterprises. The methods cannot be applied in control systems directly.

A paper [8] is about of compensation disturbances in pictures by intermediate matrixes of color and grayscale pixels. A propos, examples of coal flotation pictures listed in the paper are high quality, and they are obtained in a laboratory machine with a very good lighting. Authors [9] also created a laboratory coal flotation machine with multisource lighting to increase a quality of polyhedral bubbles detection. But they reached only 5-second period of captured video processing. This period is very suitable but it is impossible to create such lighting conditions in an enterprise.

Authors [7] have suggested using of flares from bubbles instead of bubbles borders identification. This method is developed to an experimental software realization in [10], where additional problems linked to real lighting conditions and computation complexity are described. Some of them are solved in [11] using a video shot on a real flotation machine in JSC “Uralkali” (Russian Federation, Perm region). So the main aim of the paper is to improve the algorithms and to apply them to transition processes parameters identification.

2. Materials and methods

The experiment is made in 1st and 3rd chambers of enterprise flotation machine with a compact lighting source. Flotation reagents are injected in these chambers. Precision values of flows cannot be posted here, but flow in the 1st chamber is quite bigger then in 3rd. We used a wide-angle video recorder with a 1980*1200 resolution and 50 fps. We cut a rectangle region of interest between an axe of a foam driver and a chamber wall (Figure 1) for flare identification.

Figure 1. Source frame captured from video of the Al₂O₃ powder.
A reagent flow to the 1st chamber was decreased by 1/3 when recording. A transition process begins immediately. We can observe some changes in the foam visually. After the process ends we restored the flow and recorded the video until changes are end. We can not see some transitional processes in 3nd chamber when the reagent flow was stopped at all, so only results was obtained on 1st chamber are discussed below.

We solved the next tasks when processing the video:

1. The foam driver exclusion from the frames by identifying flares features on points “A” and “B” (Figure 2).
2. An optimal binarization threshold calculation when maximum flares are determined in the frame.
3. Transition process detection by change of flares number with the optimal threshold.

![Figure 2](image1.png)

**Figure 2.** Specific character of the medium luminosity caused by the foam driver.

The optimal threshold of binarization could be determined for every frame but it is impossible in real time by a long time of computations (70-300 sec for one frame depending of luminosity and bubbles count). That is why we approximated it from the medium luminosity of the frame. The approximation must be made one time for every chamber and every lighting condition (Figure 3)

![Figure 3](image2.png)

**Figure 3.** Dependence between the medium frame luminosity and the optimal binarization threshold.
Using of approximation threshold leads to error about 7-10% in bubbles count. It is not so small, but is it possible to identify a transition process, is a question.

3. Results and discussion

We combined a trend of estimated transition process with a trend of bubbles count in 1st and 3nd chambers after the reagents flow to the 1st chamber was changed (Figure 4).

![Figure 4. Ideal and real trends of transition processes](image)

4. Conclusion

As a result we obtained obvious dependence between the real transition process and the count of bubbles flares in the frame. If we apologize the chamber is a first stage (ideal mixing) object with transition function \( W(s) = \frac{K}{T \cdot s + 1} \), we obtained a value \( T \approx 8.3 \) sec for the 1st chamber and \( T \approx 8.6 \) sec for the 3nd chamber. It is very close to \( T = 7.6...10 \) sec from other researchers ([for example, 12]). So there are no contradictions with a previously known data at least. Meanwhile the bubbles count is near constant when there are no changes in reagent flows. New processing algorithms are quite quickly as for 15-30 ms per frame, it is quite enough for the real using.

So the aim is reached. We modified algorithms of video processing so the transition processes can be detected automatically. As a result we can use the recognizing as for alarm systems so for decision support too.

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