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# Computer-Aided Quantitative Observation of a Crystallization Process

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**Abstract**

As we all know, experiments and measuring play very important role in the education and science. Our aim is to develop an educational aid by which we can separate the making and measuring of chemical experiments for studying crystallization process with preserving validity of measuring. To realize this aim we record the experiment on video then a suitable computer program can evaluate it anytime and can display the results of measuring in an appropriate form. The recording can be also used for studying the phenomenon without experimental devices being there because these recordings can be transmitted through an appropriate channel. After recording an acceptable number of experiments students can carry out and reproduce these measurements in an interactive way at home on their own computers if they have the program.

*Keywords:* image processing, computer-aided quantitative measuring, crystal growth, crystallization process

## 1. Motivation

A number of national and international surveys assessing the results of publications reported about some kind of crisis in the field of science subjects mainly in Physics, Chemistry and Mathematics. Understanding of the phenomenon of nature – not only in education process – is possible through the models made of them. The first important element is the experimental measuring on which the mathematical description of the internal correlation of the phenomenon can be based. Nowadays the computer is available at different levels of education and it is a kind of educational tool which can be used in many ways. Our aim is to present, how can we get information from video records a simple way by computer.

## 2. Introduction

It is beyond dispute, that the computer simulation is a really effective tool in the fields of studying, showing of nature, so it can be a useful method in education, as well. The extent to which it can be applicable depends on the mathematical model on which the simulation is based.

Just imagine how we can get to know the reality only through studying the virtual world. This contradiction originates from the modelling itself as a method, as every model can only represent the image of reality from a certain point of view. It is our responsibility to apply appropriate models.

There is another way to show the phenomena of nature. A video recording may be more applicable to show phenomena, at the same time it is possible to transmit them an in electronic form. Although, the recordings fix pictures of real phenomena they can not reflect the quantitative changes at the required promptness. Consequently, they can be used for demonstrative purposes and cannot be used for the numerical representation of the results of the experiments.

## 3. Crystallization Process of NaAc

We should choose a simple process to show this phenomenon. The well known hand warmer is filled with the supersaturated solution of NaAc. It can accumulate the warm of boiling water. When we click the piece of metal inside the tool we get the stored energy during its crystallization process.

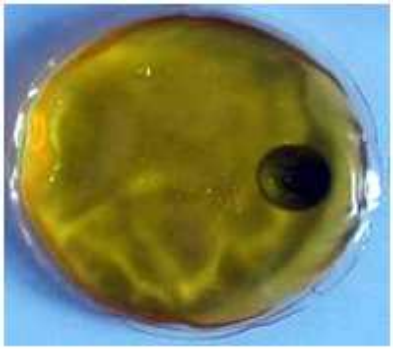

Figure 1

This simple experiment can be leaded without mentioned tool too in lab or at home in a test-tube. It does not require complicated tools and materials. In this chase we can start crystallization by adding a piece of crystal. The pictures show the process second by second. It seems to be linear correlation between the time and the quantity of crystal.

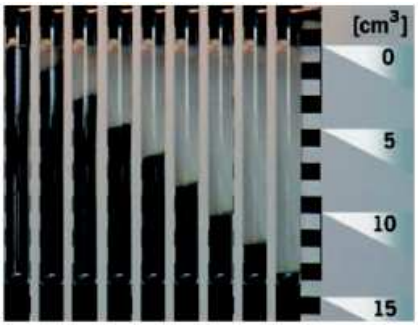


Figure 2: Sodium acetate crystallization in test-tube

## 4. Exploration of the phenomenon

It is important to note that the speed of the growth of the crystal (the growth of amount of substance of solid phase during a given period of time) depends on the area of the crystal and the concentration of the liquid at a given moment. During the experiment we produced the supersaturated solution of sodium-acetate. The ionic crystal contains water molecules bound with in its crystal lattice.

The quantity of this water characterizes the given ionic crystals. In the case of NaAc 1 mole material has 3 moles water ($NaAc\breve{}3H_2O$ sodium acetate trihydrate). The water escapes from the lattice during the heating and the material dissolves in this water that is why the proportion of NaAc and the water is 1:3 in the supersaturated solution, too. During the process the proportion of amounts of substances built in to the lattice will be the same, so the concentration of the liquid remains constant. The rate of water and NaAc is the same in the increasing crystal too.

The pictures show, how the crystal grows in a plane and other parts of pictures do not change.

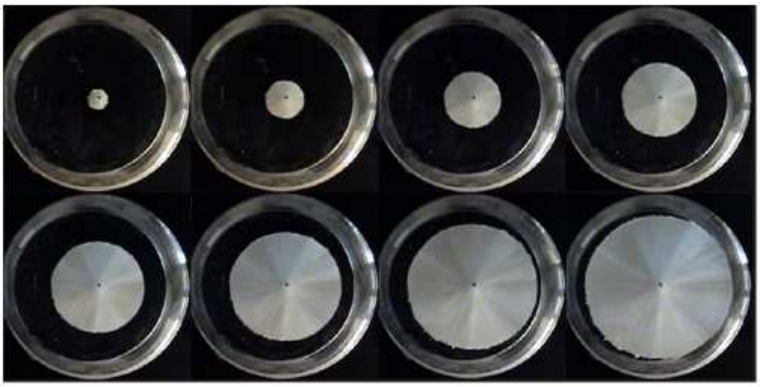

Figure 3

# 5. Measurement of the computer evaluation of images

The first step of the computer image processing is useful to separate the background from other pixels. In our case, we have the background in a pixel, which does not change during the recording, so it does not belong to the object you want to track.

The nature of the problem allows the simplest background model to apply when we assume that the brightness of the pixels in the motion regardless, just for the camera built CCD from having a way similar to the measurement results vary according to normal distribution. Thus, if a pixel is significantly different from the brilliance of a few consecutive frames (frame) the average of corresponding pixels radiance values typical, then the pixels are not considered background point, but we say it belongs to the moving object.

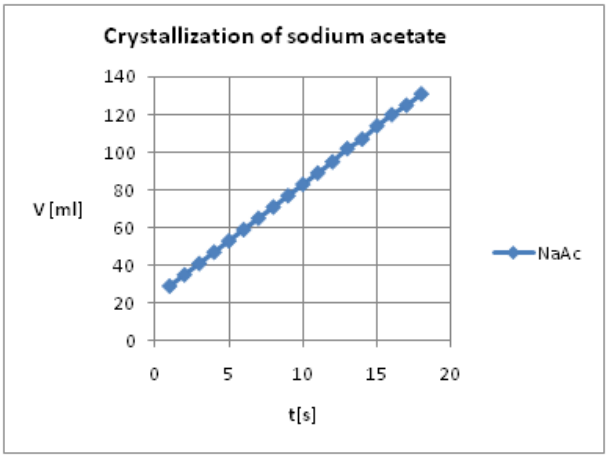


Figure 4: Crystallization of sodium acetatethe diameter of the crystal changes over time

The evaluation of the images it captures the special character is used up to the test object is essentially a constant background moves. This circumstance into account the problem becomes quite manageable. Since each pixel in these images is the color codes stored in the memory, each image of a matrix is available.

Thus, if the successive images to be processed $n$ rows and $m$ pixels per line are available. Each image corresponds to a type $n$ $m$ matrix, where the i$^{th}$ row j$^{th}$ element stores the appropriate image to the pixel of $i^{th}$ row $j^{th}$ the necessary information. Our task is to create the information, which can express the difference between two pictures. Let $A = (a)_{nm}$ and $B = (b)_{nm}$ the two matrices the results of gray-scale image processing. Now we can calculate the $c_{ij}$ element of $C$ according to the rule below:

$$c_{ij} = \begin{cases} |b_{ij} - a_{ij}| & if \;\; b_{ij} \geq \; a_{ij} \\ 0 & if \; b_{ij} < a_{ij} \end{cases}$$

The elements of $C$ will be close to zero where the pixels of the picture did not change (invariable pixels), otherwise the given element of $C$ will be differ significantly from zero where the two images differ significantly (pixels of moving surface). To sum up these elements of $C$ indicate changes in the motion picture.

We can separate the two groups of points (invariable pixels and pixels of moving surface) better, if the elements $cij$ of low-value bits is simply omitted. Moreover, this solution also simplifies the evaluation of the subsequent image unit.
Crystallization process of sodium acetate can be characterize well by change of the quantity of crystal over time. To calculate the volume of crystal at the given moment we have to estimate the diameter of it.

If the elements of $C$ matrix is added in each columns and each rows, we can get the $n$-element vector $V$ and the $m$-element vector elements of $W$. ($V$ and $W$ are sequences.) Both sequences have two local maximums. The distance of them is a good starting point to guess the diameter of the crystal.

$$v_i = \sum_{j=1}^{m} c_{ij}, \quad w_i = \sum_{i=1}^{n} c_{ij},$$

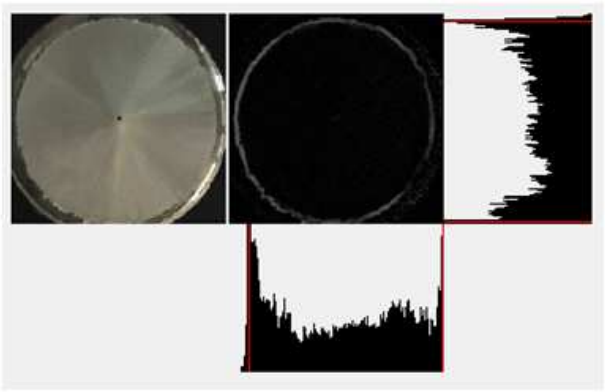

Figure 5

A simple algorithm allows determine the positions of maximum elements. Based on, knowing this positions we can calculate the diameter of growing crystal from which is not too complicated problem to determine the volume of material frame by frame.

## 6. Future works

Above we describe an example how to get important information about an experiment from a video record. In a similar way we can develop other educational software, which will be allows to observe different physical and chemical phenomenon such as periodic motions.

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