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Observation of mechanical movements through virtual experiments*

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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 physical experiments for studying mechanical movements with preserving their validity of measuring.
To realise 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 also be 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 the students can carry out and reproduce these measurings in an interactive way at home on their own computers if they have the program.

Categories and Subject Descriptors: K.3.1 [computer uses in education]; J.2 [physical sciences and engineering], Physics; G.3 [probability and statistics] *Experimental design, Multivariate statistics*

Key Words and Phrases: measuring by computer, mechanical motions, education, learning at home

1. Introduction

First and foremost, we would like to give you a short explanation to the title of our paper.
Actually, by observation of mechanical movements we mean only one kind of movements, it is rectilinear motion.

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Secondly, the word ‘virtual’ needs further interpretation because the experiments are real, but the measuring can be done later at any time with the help of a computer. That is why we may call it *semi-virtual* experiment.

We have to mention the fact that studying of mechanical motion is a compulsory material for different age groups in the Hungarian educational system.

1.1. Measuring by computer

We have sorts of devices at hand, which can help understanding the phenomena themselves in this field. There exist other techniques, which can resolve this problem with the help of computer too.

1.1.1. An other technique

For instance, the well known experimental device which is supplied with some sensors at equal distance from each other, which can measure the time in which it takes rout between the sensors. It can measure times of taking equal routs.

This solution has some drawbacks from our point of view:

¬ it needs a special hardware

¬ the numbers of samples are usually poor

¬ both the experimental tools and the computer are necessary, consequently, experiment can not be done at home.

1.1.2. Basic elements of our method

Our aim is to develop an experimental method with which we can separate the measuring from the making experiment and it can be done with on own computer at home.

The basic idea is to shoot a film of experiment and it can be evaluated at any time by a computer. In this method there is no direct connection between the experimental device and the computer that is why no special hardware is necessary.

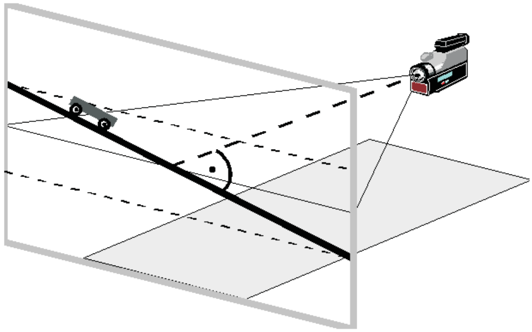

Figure 1: Location of camera and experimental device

We place the handy cam at an appropriate distance from the plane of the rout perpendicularly (Figure 1). The camera can record 25 pictures per seconds. If we ware able to determine the location of the moving object on the given pictures we could calculate the length of the rout taken in one twenty fifth of a second. Of course, we can get the distance in pixels.

The only thing they have to do is to modify the usual experimental device to a certain amount, which can be done easily.

2. Detailed description of our method

2.1. Description of our experimental device

To carry out our plan we had to modify the usual experimental device. Namely, it had to be supplied with three LED-s and four switches.

In the figure 2 we can see the rail on which the carriage rolls on. The rail has 2 LED-s on both ends of it. (The distance between them is 1.8 m. It has to be known to express the rout taken in meters.) The picture shows the carriage with a LED and the launching object too.

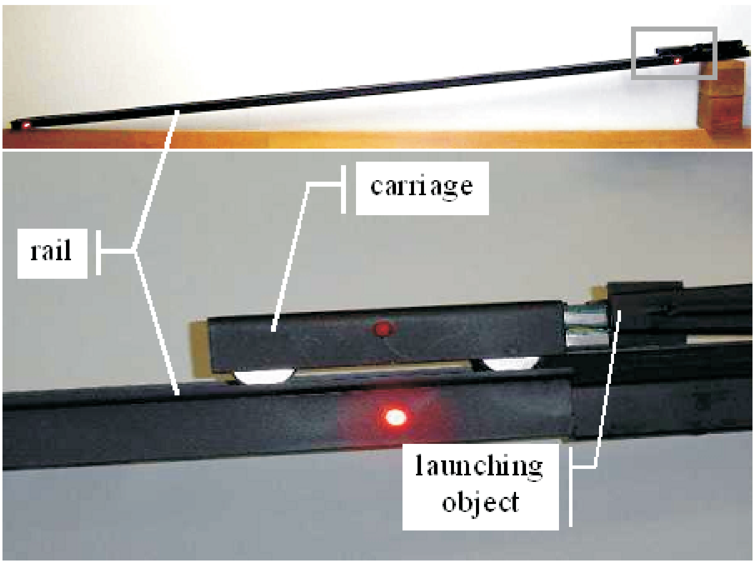

Figure 2: experimental device developed by us

The launcher can control the LED-s and start the carriage too.

2.2. Structure of the recordings

Recordings of the experiments can be divided into 3 distinctive parts (Figure 3). They can provide a simpler and more reliable way of evaluation.

They are the following:

a ***Standstill period***: we will compare the forthcoming pictures to this. It helps to estimate the location of LED-s. (It is supposed that the background does not change during the recording. It takes few seconds.)

b ***Validation***: the distance between spotlights is 1.8 **m**. Through this we can express a distance in **m**.

c ***Motion***: only the LED of the moving object lights, we have to find its location picture by picture.

Earlier we thought the dark background would be advantageous, but we realised that it did not matter at all, because we managed to find an appropriate method to express the difference between two pictures.

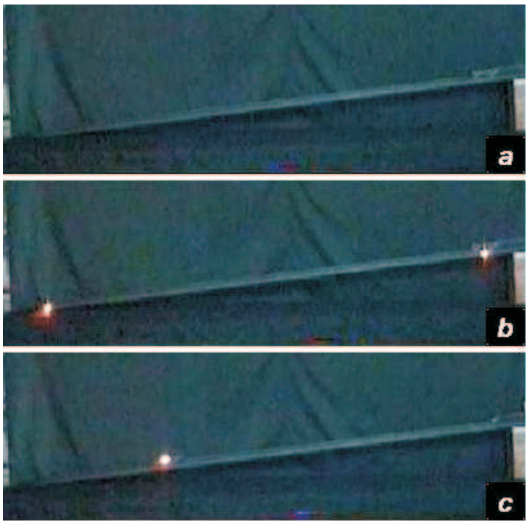

Figure 3: The three phases of the recordings

2.3. Evaluation of the recordings

How could the location of the object be determined?

The applied procedure should be sensitive to the changing of the successive pictures, any other element of the picture is noise. We have to observe the same point of the moving object. That is why we have to be able to separate the same point of it every time. Our task is to create the information, which can express the difference between two pictures. In order to achieve our aim, we have to subtract the very first picture from the given one, pixel by pixel in a special way (Figure 4).

$$c_{i,j} = \begin{cases} b_{i,j} - a_{i,j} & \text{, if } b_{i,j} \geq a_{i,j} \\ 0 & \text{, otherwise} \end{cases}$$

($b_{i,j}$, $a_{i,j}$, $c_{i,j}$ are the colourcodes of the pixels in the ith rows and jth columns of the pictures)

The figure we gained this way is similar to a two-dimensional scatterplot (Figure 5). Each point can be characterised by the distance they have from the centre of the spotlight.

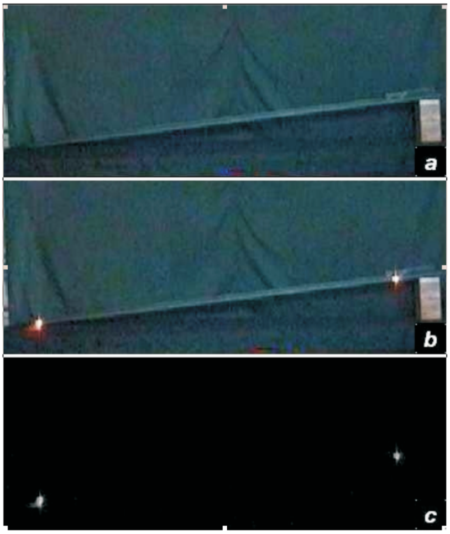

Figure 4: 'c=b-a'

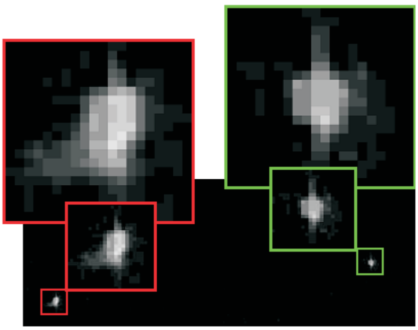

Figure 5: The brighter a point is the closer it is to the centre

The brighter a point is the closer it is to the centre. This is expressed by their colourcode. Our aim is to find the centres of the LED-s, so we summarise the colourcodes of pixels in each column and each row. This way we can arrive at the following diagram (Figure 6).

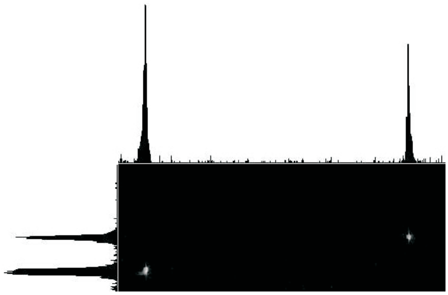

Figure 6: Relation between location of spotlights and diagrams

The significant changes on the diagram indicate the locations of the LED-s. The location of the centre of an LED can be estimated in a statistical way.

3. Discussion

Taking everything into account, the way of determination the location of an object can be widely applied in this field.
We are planning to develop other experimental devices and a computer program with which we will be able to observe, study and teach other types of motions.

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