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Positioning system in microscopic spaces (μ-GPS)

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Abstract. ***The study aims for the development of a unique positioning system in the world of microscopy consisting of a transducer and software application. The technology used is based on image processing which creates a special hardware (transducer). The virtual labeling is the essential idea of this system. It synchronizes two essential things: the actual object and a set of exact coordinates to be retained in a database, with the ultimate goal of relocating them by bringing them into the visual field.***

Keywords: virtual labeling, image processing, absolute coordinates.

1. INTRODUCTION

The paper proposes the development of a unique positioning system in the world of microscopy consisting of a transducer and software application, designed to be universally compatible with any type of microscope. The technology used in this case is based on image processing, to obtain a particular transducer that has the ability to work with absolute coordinates. Virtual labeling is the basic idea of this system, overlapping the main microscope images with the absolute coordinates. The virtual labeling synchronizes the two essential things: the real object seen in the microscopic field and a set of absolute coordinates that will be saved in a database along with a name of your choice. The precision used to label the virtual objects in the microscopic field can be improved and is actually 1 micrometer mentioning that if the system is equipped with a high resolution video camera for example a 4k (3840 pixels × 2160 lines) resolution camera the precision of the system greatly increases, but the idea that the user can save the actual location of the object and the ability to revert to its location are two exciting utilities when it comes to the world of microscopy. The system is unique and nothing remotely close had never been developed by others.

Image processing is a relatively recent domain that is developing rapidly. Its applications are found everywhere in medicine, the military, industry, arts and in the environment where information is represented as images. The main application purpose is to improve the data contained in images which are going to be interpreted by a human subject or for the artificial vision of robots [1].

Artificial vision is the domain that concludes data/information from images using mathematical, geometric, statistical, physics, and automatic learning theory methods. Image processing is becoming more and more important in many fields of application. The active vision, such as for autonomous vehicles, requires a very high amount of processing power in order to be able to operate in real time. In this case, the vision allows the development of more flexible and intelligent systems than in other sensory systems met in the world. There is a need to hurry the process of non-critical image processing such as medical imaging or satellite imagery. While large SIMD (Single Instruction Multiple Data) systems such as Connection Machine or MasPar have passed, the concept can be used for imbedded systems. The ideal concept of having a single processor ALU (Arithmetic Logic Unit) for each pixel in an image allows a very simple and natural explanation of the image processing process [2].

Image processing usually refers to digital image processing, but optical and analog image processing also are possible. The acquisition of images (producing the input image in the first place) is referred to as imaging [3].

Many of the digital image processing techniques or digital image processing as it was often called, were developed in the 1960s to Jet Propulsion Laboratory, MIT, Bell Labs, University of Maryland and a few other places with application to satellite images, conversion of standard wire photos, medical imaging and so on. Yet the processing cost was quite high with the equipment of calculation of that time. In the 1970s, digital processing of images has proliferated when less expensive computers have become available. Images could then be processed in real time. As computers have become faster and more and more powerful, they have begun to take over the role of dedicated hardware for all operations. With fast computers and signal processors available in the 2000s, digital image processing became the biggest processing industry. Digital processing technology of imaging for medical applications has been introduced in Space Technology Hall of Fame in 1994 [4-5].

Digital image processing allows for the use of more complex algorithms for image processing and can therefore provide both more sophisticated performances at simple tasks and the implementation of methods that would be possible by analogy.

Uniquely, digital image processing is the only practical technology used for:
- Classification
- Extraction of elements
- Recognition of forms
- Projection
- Wide signal analysis

Some techniques that are used in digital image processing include [6]:

- Analysis of the main components;
- Analysis of independent components;
- Hidden Markov Models;
- Partial differential equations;
- Self-organized maps;
- Neural networks;
- Pixelation.

1.1 The principle of functioning

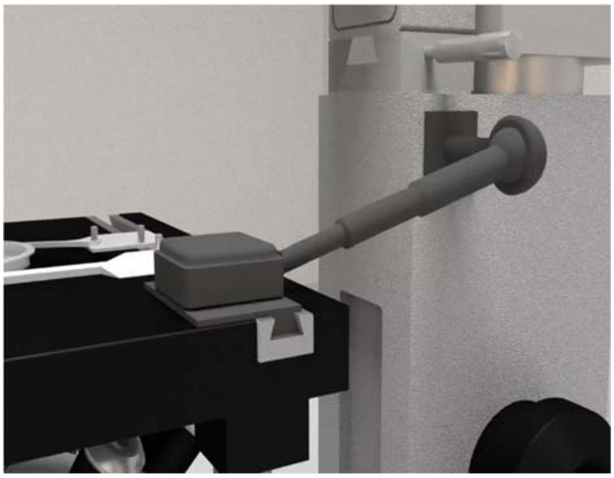

Figure 1. Absolute coordinate transducer (commercial system concept).

Figure 1 shows the concept of a transducer, which is designed to be attached to any microscope without requiring any prior technical data. Moreover, the transducer arm can be easily adjusted in order to adapt to an existing microscope. The transducer is the hardware part of the system designed to collect the position of the microscope table.

Figure 2. The video camera of the labeling system

Figure 2 shows the camcorder that is used to collect the real imagines from the microscope. It works in sync with the transducer, providing real-world microscopic space, the system collects and save the position of the file and labeling the real object in the graphical interface of the developed program. The video camera and the transducer of Figure 1 work wirelessly with the developed application which makes it easy to install and operate the system.

1.2 Software application

The main part of the positioning system is the software application that was specially design to receive data from the transducer and the camcorder and synchronize them to make the system work flawlessly and always bring the saved object in the visual field of view.

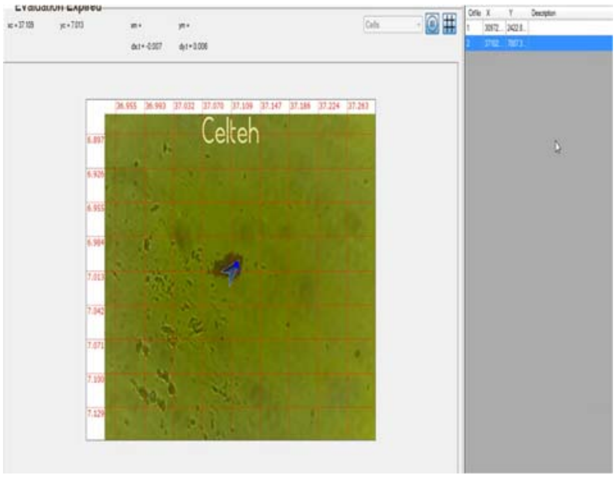

Figure 3. System interface

Figure 3 shows the system interface on which the human subject use for virtual tagging, which is intuitive and very easy to use. The system is designed to work simultaneously with an electrically or manually controlled microscopic table, the object retained in the database being brought into the visual field of the microscope. We can see the actual position defined in the program with XC and YC, XC is for the X axis and YC is for the Y axis. Other coordinates such as DX.T and DY.T are the remaining distances from the saved object mentioning that when the DX.T and DY.T are 0, the object is in the exact position when was first tagged. Dimensions are in micrometers.

Marked locations

CrtNo	X	Y	Description
1	33,357...	9,6317...	
2	33,367...	9,6309...	
3	33,377...	9,6309...	
4	33,387...	9,6301...	
5	33,397...	9,6309...	
6	33,417...	9,6309...	
7	33,427...	9,6301...	
8	33,258...	9,6571...	
9	33,208...	9,6571...	

Figure 4. Coordinates of saved objects

Figure 4 shows the location of objects saved by the user in the form of coordinates and description.

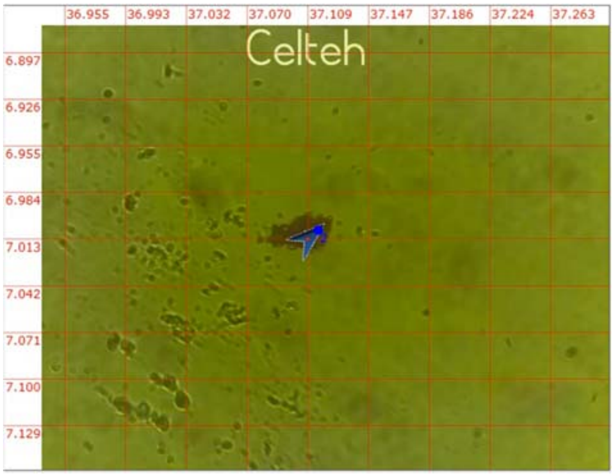

Figure 5. The real image of the microscopic space

Figure 5 shows the real image in the microscopic space provided by the video camera seen in Figure 2.

The positioning system has been built to be used to measure objects/distances between them, and shows a very high accuracy in experiments, and some functions of characterization of the measured objects will be implemented in the future.

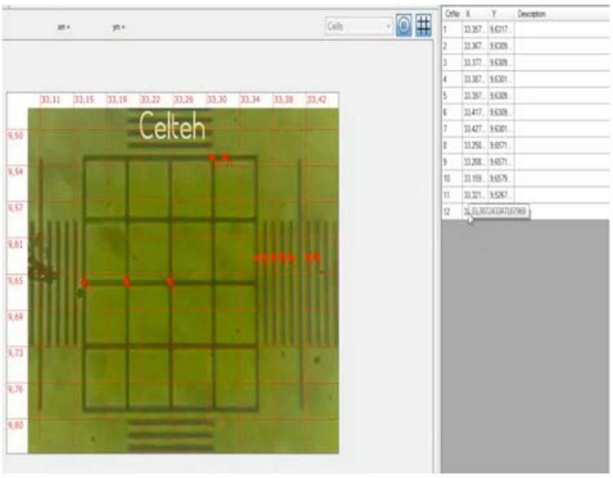

Figure 6. Working accuracy tests

In Figure 6 we can analyze the precision of the localization system by using a micrometric scale. The selected distances correspond to the micrometric distances between the ruler lines.

The positioning system (μ-GPS) is an ingenious way to retain the position of one or more objects indicated by the user with the ultimate goal of relocating by bringing them into the field of view of the microscope whenever necessary. The applicability of the system is vast, and can be used in various fields: biotechnology, materials science, chemistry, and any type of field working at microscopic level.
Note: The experimental model of the concise system presented in this report was developed in the prototype laboratory of Celteh Mezotronic in 2016 by a research-development team in which I was an active member.

2. ACKNOWLEDGMENTS

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