UTILIZATION OF VIRTUAL REALITY FOR READING THE SUPERHEATED EMULSION DETECTOR

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ABSTRACT

This paper presents a method based on Virtual Reality for reading the Superheated Emulsion Detector (Bubble Detector). The proposed method is an alternative to: automatic counters offered by the manufacturers of detectors, since they have a relatively high cost (acquisition, maintenance and periodic calibration), and visual counting of detectors, since it only has an advantage when there are a small number of bubbles. The method starts with the collection of detector’s digital images in order to obtain a sequence of images to create an animation that is displayed with the help of Virtual Reality. To this end, it is modeled, using OpenGL graphics library, a virtual environment for visualizing and manipulating virtual detector. It is made, then a calibration of this virtual environment thus ensuring the correspondence of the model with reality. The reading of the detector (bubbles count) is made visually by the user with the assistance of stereo vision and a 3D cursor to navigation, marking and counting the bubbles. The user views a further auxiliary display that shows the three-dimensional cursor position, the labeled amount of bubbles and the measured dose. After testing, the following results were achieved: better precision in counting the bubbles compared with the 10% reported by the manufacturer of the automatic reader; achieving a low cost tool that requires no calibration constant in the process of maintenance and/or lifetime; minimizing the problem of manual counting for large number of bubbles and ease of use, because can be operated by a common user.

1. INTRODUCTION

In the 50s of the twentieth century, the physicist Donald Arthur Glaser builds the Bubble Chamber, an important tool for the visualization of charged particles moving inside. The work on the Bubble Chamber influenced Robert E. Apfel has created a neutron detector...
called "Superheated Droplet Detector". Harry Ing and H. C. Birnboin suggest, then an enhancement of this detector, as the use of polymers, appearing officially superheated emulsion detectors or bubble detectors.

Currently, superheated emulsion detectors, consist of a polycarbonate ampoule filled with a polymer in gel form, which are dispersed droplets of superheated liquid. Two companies are the biggest manufacturers detectors bubbles, they are: Apfel Enterprises, manufacturer of Superheated Drop Detector and Bubble Technology Industries, manufacturer of Bubble Detector. The key point in the use of the detector is counting bubbles after the detector interact with a neutron field. The number of droplets provides a direct measure of the neutron dose equivalent to a tissue [1]. The company Bubble Technology Industries offers, to detectors bubble buyers, a gear for your score. This is the BDR-III. The auto reader bubbles BDR-III™ is the solution provided for a large number of detectors. The BDR-III provides barcode reading and counting with fully automatic machine vision that provides data files compatible with an instrument compact and simple to use [2]. To allow the user to verify the correct operation of the BDR-III, a calibration detector is provided with each reader. This calibration detector has a fixed number of bubbles and has the same size as a BD-PND™ (Personal Neutron Dosimeter Bubble Detector). The number of bubbles is provided in the system documentation. The reader BRD-III is acting together with the specification that the count of bubbles is observed ± 10% of the count of the manufacturer [2]; it means that has a bypass counting. Additional calibration detectors can be purchased separately for the reader BDR-III as is required, again worth remembering that the manufacturer recommends that detectors calibration are changed periodically for optimum performance in terms of verification system BDR-III. So it becomes interesting to the creation of an alternative method that can do the counting of bubbles and it can, therefore, reduce the maintenance cost with the cyclic purchase of calibration detectors.

Thus, the present work deals with the creation of a computer interface that has the ability to provide its user viewing the detector, and that can interact with this manipulating its spatial position (with the application of steps capable of rotating the detector on the vertical axis) or by checking the bubbles through a mode of interaction space viewed within the detector and finally providing the number of bubbles counted, or marked. With the use of stereo vision technology (3-D) visualization of the detector as well as the visualization of spatial interaction from the user, it presents a more realistic view of this type of simulation provide a different look from what can only be observed on the flat screen monitor of a computer with normal vision.

2. CONSTRUCTION OF INTERFACE

For the construction of computational interface of this study, it was established the following script to be considered so that the elements of each of these steps were present and well represented in the graphical interface:

- Acquisition of digital images of the detector;
- Modeling the virtual environment (OpenGL);
- Calibration of the images with the virtual environment;
- Development of the interaction with the virtual environment;
- Verification of interface usability.
2.1. Acquisition of Digital Imaging Detector

In a first action has been established that for digital images having good detector should be chosen in the first place a bubble detector that was in good condition, that is, a detector which possess a reasonable amount of bubbles, it possess one ampoule that was not marked with scratches, dirt or any other imperfection that might interfere with the visualization of bubbles and hence difficulty in counting them. Was presented two detectors of Bubble Technology Industries (BTI), Model BDS-10. One was promptly dismissed and returned to the sector responsible at IEN because it has imperfections in the bubbles due to the long time elapsed since the formation of bubbles and due to ambient temperature conditions that led some bubbles to lose their sharpness when viewed, taking with it a certain difficulty in counting immediately some bubbles. Thus the detector to be used in the construction of the interface is defined. Figure 2.1 shows the detector chosen.

![Detector chosen to act in interface.](image)

Figure 2.1: Detector chosen to act in interface.

Thus were gathered from digital images of the sequential detector. Figure 2.2 shows the sequence of five (5) first pictures obtained from a total of 180 (one hundred), that is, every two (2) degrees was obtained digital image detector.
2.2. Modeling of Virtual Environment (OpenGl)

At this stage it was established modeling to create a program in OpenGL that provides a user with a screen where the display should be provided through the detector and any commands you apply (in virtual form) certain steps in the detector principle should be equal to two (2) degrees that were obtained in the acquisition of images and otherwise command could be marked bubbles contained in the images, which should also accompany the rotation (pitch) obtained. With this should be built to provide a counter to the end of the work the count bubbles marked. Basically, the program runs through the creation of a cube (virtual) where through the OpenGL is displayed whenever one of its faces. This cube is static, i.e., no move command is applied to it. From then is made to insert an animation of the images of the detector in the form of a texture on the face of the cube. All 180 (one hundred eighty) images are stored in a folder and with the aid of a file ".txt". The correct sequence is defined based on titles that each image gets to be named. Thus it was possible to create a command that inserts the correct image for the animation to be displayed accurately. How the program should be viewed with the aid of stereo vision, an arrangement that is done, if the trigger stereo vision, two images are inserted at the same time (always in the form of texture) on the face of the cube, thus creating two images which are superimposed, the principle of stereo vision. When certain command trigger (it was decided to use the "r" key command in reference to rotate), there is the exchange of the two initial images following two images.
Thus, the user will have a clear view of the detector by turning to his command in its vertical axis. Figure 2.3 shows the result obtained in this construction.

![Figure 2.3: Preliminary results obtained for the interface.](image)

2.3. Calibration of the Images with the Virtual Environment

A perfect calibration of images begins with the perfect alignment of sequential images obtained during collection of images. Figure 2.4 displays the symmetry obtained. Note that perfect symmetry is given when \(A = B = D\) and \(C\), or when \(A = D\).

![Figure 2.4: Perfect symmetry image.](image)
The calibration of the images with the virtual environment is necessary for the marking display and the blisters of the detector correspond to reality, or the vision and virtual trajectory of bubbles and/or markings bubble detector must be identical to that found in reality. This requires that sphere markers bubbles, markings bubbles, bubbles and the images viewed by the user are in perfect harmony. Thus the user to view the detector interface will track the spatial positioning of all the bubbles he can view and thus mark and count. As the bubbles perform a movement cyclic (ring) around the vertical axis, the markings of bubbles (in bead form) should be instructed to complete such a cycle as a function of sine and cosine of the angle formed by the step of animation. Figure 2.5 shows a section of the detector. The horizontal line directed to the right, is the X-axis in Cartesian coordinates and the vertical line directed from the top down is the Z-axis of Cartesian coordinates. It is evident that the Y-axis coordinate is not shown in the figure, but it lies on the line perpendicular to the plane of the drawing and is directed out of the plane of the drawing.

![Figure 2.5: Representation of a section of the detector.](image)

Assuming a green bubble that lies at a position $x, z$ making a turn (clockwise) of $\theta$ radians, we have a new position $x', z'$ to the green bubble. We have $x' = x \cos \theta$ and $z' = z \sin \theta$ can be written as:

$$x'z' = xz \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix}$$

Solving, we find:

$$x' = x \cos \theta - z \sin \theta$$

$$z' = x \sin \theta + z \cos \theta$$

Figure 2.6 shows the section of the program that provides such instruction to the trajectories for $x'$ and $z'$. Note that the portion of the program is the function responsible for inserting the spheres, ie, the function for handling mouse events. It is also shown that while with the left mouse button the user enters a sphere, with the right mouse button the user can clear the sphere.
2.4. Development of Interaction with the Virtual Environment

So that the user can get a sense of space 3 (three) dimensions for marking bubbles came up the drive in a straight black color that is applied to the interface, initially in the center of orthogonal lines drawn on the interface. With the help of the arrow keys of the computer keyboard there is a free end of the line (the other end of the line remains fixed in the center of the straight lines orthogonal), which the user can move anywhere on the screen interface. There is a small red sphere at the tip of the line whose function is to further improve the dimensional visualization of the path taken by the line. By positioning the little red sphere on a bubble detector, this can be checked by triggering the left mouse button, when you trigger the right mouse button the sphere is cleared. With that and the drive of the "r" key on the keyboard, the detector can rotate thereby providing new display of bubbles that have not been marked. Figure 2.7 shows the function related to the processing of the keyboard where there is a "switch" that performs animation to the images of the detector with the aid of the "r" key.
Figure 2.7: Function for the treatment of rotating detector.

The user still displays a help screen that also displays the amount of bubbles marked and three-dimensional positioning of the small red sphere (cursor used to mark the bubbles) the line also contains the relevant fields on the attributes of the detector and as the date marking. Figure 2.8 shows the interface with the auxiliary display.

Figure 2.8: Interface with your main screen and auxiliary screen.
In Figure 2.9, we have an approximation (zoom) for the best view of the detector, spheres, bubbles and straight assist in marking bubbles.

![Image of bubbles and markings]

**Figure 2.9: View the marking bubbles.**

### 2.5. Verification of Interface Usability

Thus, it was performed a series of tests in order to verify the usability of the interface using a computer equipped with specific video card for using stereo vision and a projector that makes use of stereo vision (devices that are part of the heritage of IEN). With the use of the computer and monitor, because it is a video monitor and passive stereo glasses with filter, there is the need for a good positioning user facing this since about the use of the projector, even though it is also stereo vision and passive filter glasses, the visualization was improved.

After a user has been trained in how to use the interface and this was able to view the detector with Stereo Vision, mark all the bubbles that wished. Then, there were placed two individuals who visualized interface (with Stereo Vision), and choosing randomly a certain number of bubbles should be marked by the user and that the respective markings performed successfully. Remember that because of the inability to reproduce the user's view with Stereo Vision, there is no way to insert in this document screens in Stereo Vision user sees, but the interface can be implemented by all that have system requirements and want to check personally its functionality.

### 3. CONCLUSIONS

The present study sought to design an interface for computing the aid of counting bubbles in a superheated emulsion detector in which the user can carry out a "manual counting virtual" regardless of large or small amount of bubbles, with the aid technology Stereo Vision (3-D), so that the equipment can be excluded BDR-III of Bubble technology Industries and delete the maintenance cost with the purchase of auto calibration. For optimized display interface is
required computational auxiliary equipment such as stereo vision projector or computer monitor with stereo vision and their peripherals such as video card with support for stereo vision, active glasses, filter, etc.

This study has successfully demonstrated the possibility of using virtual reality as an alternative process of counting the bubble detector. Among the suggestions for future work include:

- Study new forms of user interaction;
- Creation of a prototype for automating the acquisition, image processing and generation of the virtual environment;
- Creation of a process for storing data relating to the counting (storage database);
- Development of an automated process for counting bubbles, making use of Artificial Intelligence, such a process can, in principle, be achieved without the need to obtain digital images of the sequence detector.

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