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Computer Generation of 3D Integral Imaging Animations

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***Abstract*—3D Holoscopic imaging (also known as Integral imaging) is a technique that is capable of creating and encoding a true volume spatial optical model of the object scene in the form of a planar intensity distribution by using unique optical component This paper presents an new technique that can produce 3D integral imaging animations *movies*, using the integral ray tracing algorithm. The main purpose of this paper is to propose a plug-in tool to interface with commercially available Ac3D Computer Graphics software package. The proposed approach is based on a 3D integral imaging ray-tracer software, multiprocessor ray tracing system, and a 3D unidirectional integral camera model. Basically, 3D camera file is required to manipulate 3D camera viewing parameters in order to have a new position of the 3D integral imaging camera. *Ac3D IIP* is especially developed in order to read the Ac3D model file format. Experimental results show validation of the new adapted software tool and tests on such as *car and roses* models. Consequently, 3D holoscopic computer animation has been created. Although a basic 3D model was used, this still showcases the principles behind 3D holoscopic imaging and it has been successfully displayed on a HoloVizio display.**

Keywords-component; Computer graphics; Generation of 3D Integral Images; Multiprocessor Ray Tracing system; Ac3D Software; 3D TV

I. INTRODUCTION

In this new developed tool, Ac3D is used to describe 3D shapes and interactive environments; the new Ac3D file format is developed and then converted to be imported by Adapted Multiprocessor ray tracing system "Tachyon". A complete plug-in software tool that implements the application programming, interface Ac3D modelling in the environment of Object-Oriented Programming in C++ and C programming language is developed and the second based on Adapted Multiprocessor ray tracing system see Figure 3. Advanced Integral Images System And Computer Generated 3D Holoscopic Images

Integral imaging is attracting a lot of attention in recent year and has been regarded as strong candidate for next generation 3D TV. A fair amount of research work has concentrated on the development of Optical and digital techniques to convert the pseudoscopic image to an orthoscopic image [1-12].

An optical configuration necessary to record one stage orthoscopic 3D integral images has been proposed [11-18] and is shown in figure 1. This employs a pair of microlens arrays placed back to back and separated by their joint focal length, which produces spatial inversion. The arrangement allows a pseudoscopic image to be transferred such that it can straddle a separate microlens recording array (close imaging). The recording micro-lens array can be put anywhere in the transferred image space to allow the desired effect to be achieved freely: The object can be entirely inside of the display, outside of the display, or even straddling the display. The space transfer imaging scheme offers the flexibility of recording the object at a desired depth.

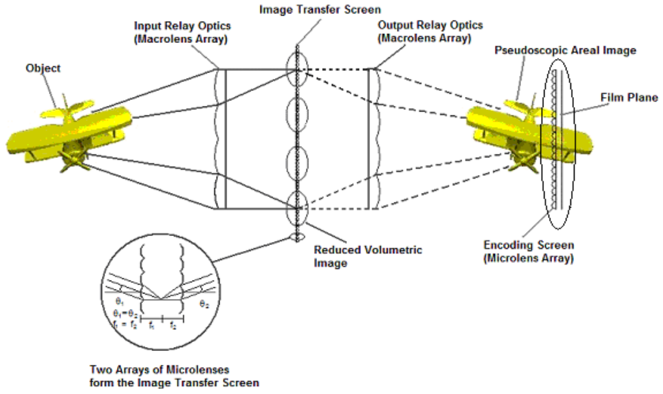


Figure 1: An advanced Integral Imaging system [96].

The system uses an additional lens array, which images the object space around the plane of the microlens combination. This arrangement has been termed a two-tier optical combination. Effectively the first macro array produces a number of pseudoscopic, laterally inverted, images around the double integral microlens screen. This image is transmitted effectively negating the sign of the input angle such that each point in object space is returned to the same position in image space. The arrangement performs pseudo phase conjugation, i.e. transfer of volumetric data in space. The image is transmitted with equal lateral longitudinal magnification, and the relative spatial co-ordinates, are preserved i.e. there is no inversion in the recorded image and no scale reduction in depth.

It is possible to capture 3D integral images electronically using a commercially available CCD array [6-12]. This form of capture requires a high resolution CCD together with specialised optical components to record the micro-images fields produced by precision micro-optics. The object/scene is recorded by a CCD placed behind the recording microlens array through a rectangular aperture. The aperture greatly affects the characteristics of the micro-images recorded. Since each micro-image is an image of the object seen through the aperture independently, its shape and size is determined by the aperture. If the field of a sub-image is fully covered by the image, it is said to be *fully-filled*, otherwise it is said to be *under-filled* or *over-filled*.

The system will record live images in a regular block pixel pattern. The planar intensity distribution representing an integral image is comprised of 2D array of $M \times M$ sub-images due to the structure of the microlens array used in the capture and replay. Sections of such typical lens array are illustrated in Figure 2. Different configuration patterns can be used in the design and manufacturing of microlens arrays as shown in figure 3. The *packing density* or *fill factor* is an important design criterion. The hexagonal arrangement of element microlenses has a higher capacity of the lens grid, and the hexagonal element shape can lead to 100% packing density without dead space [1][10]. These properties of the hexagonal microlens array make it a good choice for OII.

The resulting 3D images are termed Omnidirection Integral Images (OII) and have parallax in all directions. The rectangular aperture at the front of the camera and the regular structure of the hexagonal microlenses array used in the hexagonal grid (recording microlens array) gives rise to a regular 'brick structure' in the intensity distribution as illustrated in Figure 2.

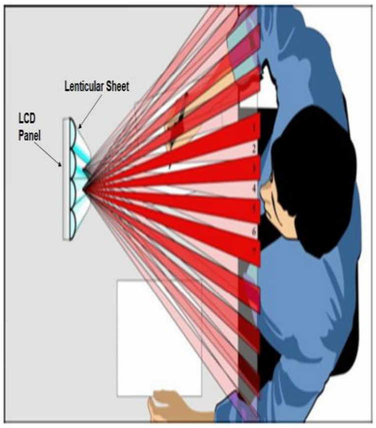
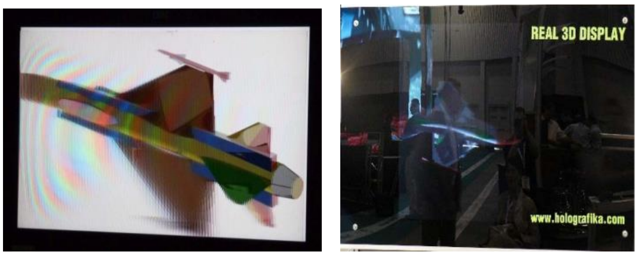


Figure 2: Multiview auto-stereoscopic display.



(a) (b)

Figure 3. (a) 3D Holoscopic Display Using and LCD panel with a Lenticular [1]. (b) Display of 3D Holoscopic Image on the Holografika System[2].

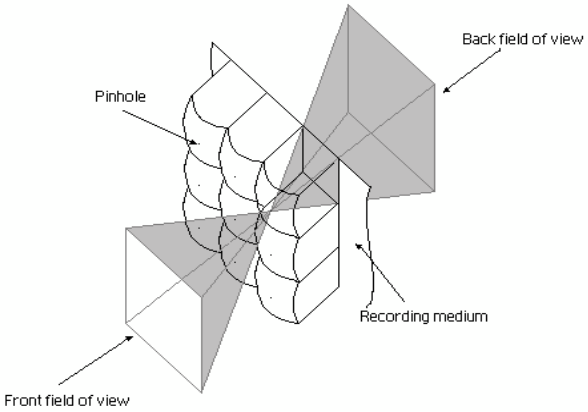


Figure 3: Micro-lens array in integral ray tracing.

The structure of the lenses and the camera model in the in 3D Integral images computer graphics affects the way primary rays are spawned as well as the spatial coherence among them.

The camera model used for each micro-lens is the pinhole approximation, where each micro-lens acts like a separate camera. The result is a set multiple cameras. Each of them records a micro-image of the virtual scene from a different angle see Figure 5. Primary rays pass through the centre of the micro-lens and the image plane. The scene image straddles the micro-lens array. Therefore there are two recording directions, in front and behind the micro-lens array. The specific characteristics of 3D integral images, allows us to deal with each cylindrical lens separate from the others, and to measure the number of pixels behind each lens, focal length and the image width. All these parameters including the number of lenslets in the virtual cylindrical array are selected on the basis of the characteristics of the display device. The pixels intensity values of the micro-image for each lenslet are read, saved, and then mapped to pixels locations on the screen so that all the vertical slots are displayed at the same time forming the 3D integral image. The location of the vertical elemental image on the computer screen is identical to the location of the corresponding lenslets in the virtual lenses array.

II. AC3D SOFTWARE

Ac3D package is designed to create 3D models for simulations, rendering ray-traced images and scientific, games, medical and general data visualization, high resolution 3D renderings, see figure 4. Ac3d has a control panel on the left; see figure 4.A, and four view windows, menu, toolbar at the top and an information bar along the bottom. Control panel is where the main controls over the selection and draw models are located. It also contains the surface-type controls, the palette of materials and the object name files. The top of the control panel shows information about the current selection.

Toolbar contains buttons for some of the most commonly used functions. View windows Ac3D starts with three two-dimensional (2D orthographic) view windows and single three-dimensional windows. The default view windows show Font, Left, Top and 3D camera angles onto the model space. Each view window has an individual menu at the top. This contains the menu for the view angle camera changing the viewpoint [13], see figure 4.

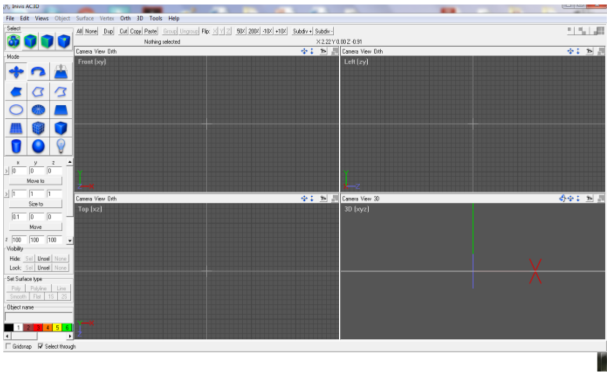


Figure 4: Ac3D computer graphics package interface [13].

III. DESIGN 3D INTEGRAL IMAGES ANIMATIONS

A software plug-in is proposed to interface the integral imaging software with commercially available computer graphics software packages such *Ac3D*. The proposed 3D integral imaging animations plug-in tool uses 3D model that is designed from a commercially available 3D Computer Graphics software package as its input. Figures 6,7 , shows the flow diagram of proposed integral imaging ray tracing algorithm. It consists of a 3D integral imaging camera model, *3D IIP*, and a 3D integral imaging renderer in order to generate a 3D integral imaging sequence of frames.

The aim of the 3D integral imaging model parser is to read and handle a stream of tokens of the scene description file format. Each token is a single world entity that describes the type of object cylinder, box, sphere, polygon, material, grouping, surfaces, texture maps, background, lights, colours, translation, and rotation, matrixes, and is followed by the data for the object. Objects may have children in other words; tokens can contain other tokens as data see Figures 5, 6.

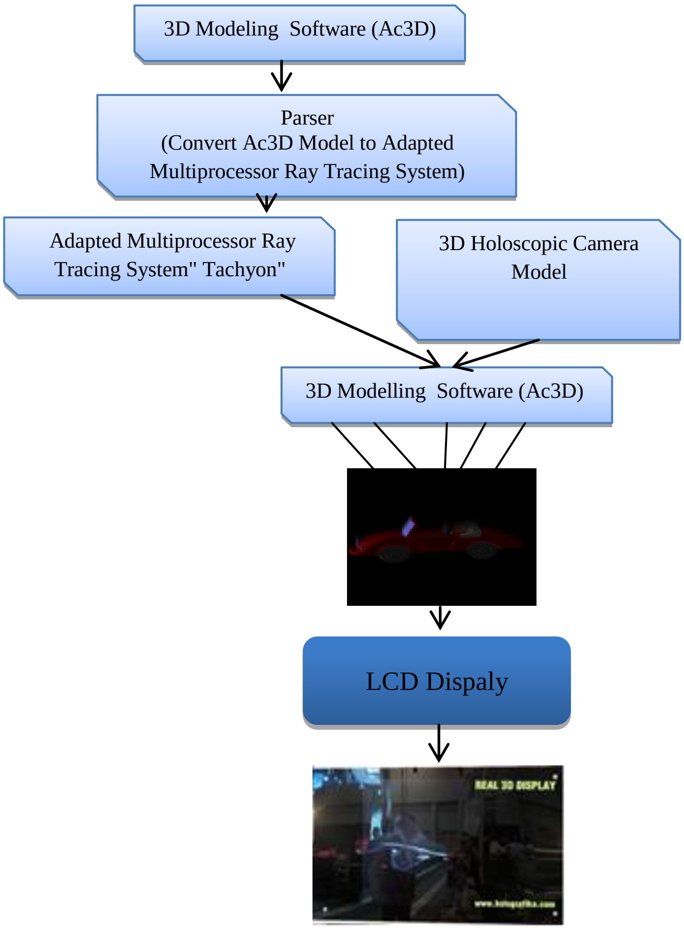


Figure 5: 3D Integral Images content parser modules diagram.

Subsequently a 3D integral imaging parser is developed. The proposed computer-generated 3D integral imaging animation technique is implemented and used to generate several sequences of photo-realistic 3D integral imaging frames. A unidirectional integral imaging camera model is adopted.

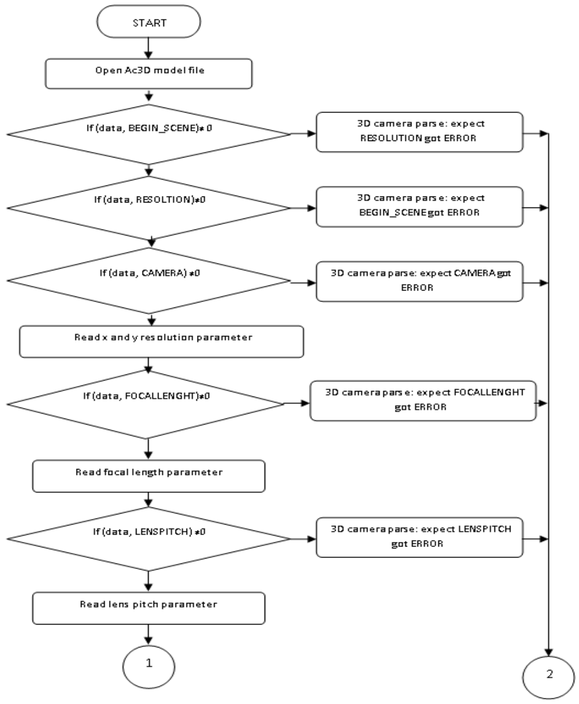
```
Read the header 3D-Model
While not end of file
   {
            Read a line
               Check first token on the line
               Handle this token's values (this might
involve reading more lines)
    }
```

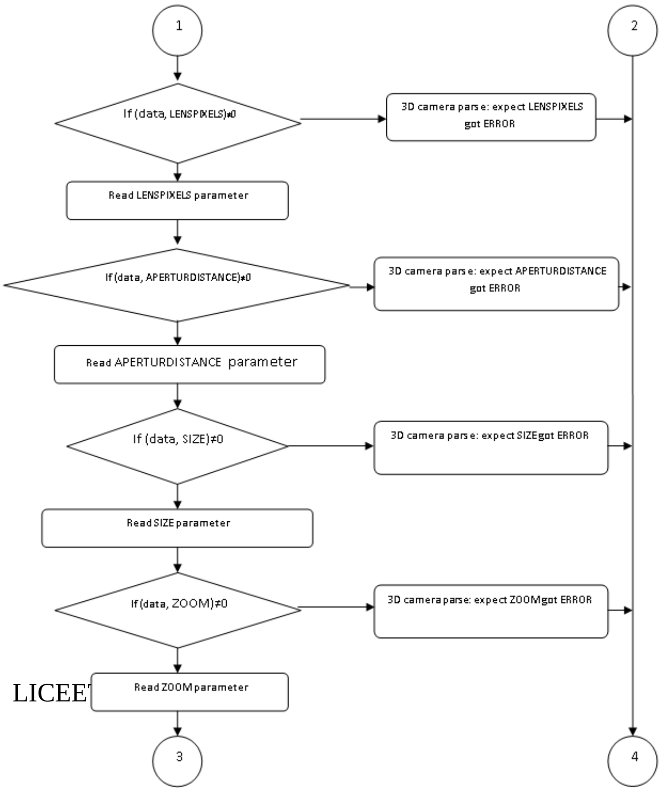
Figure 6: 3D integral imaging animations parser pseudo-code .

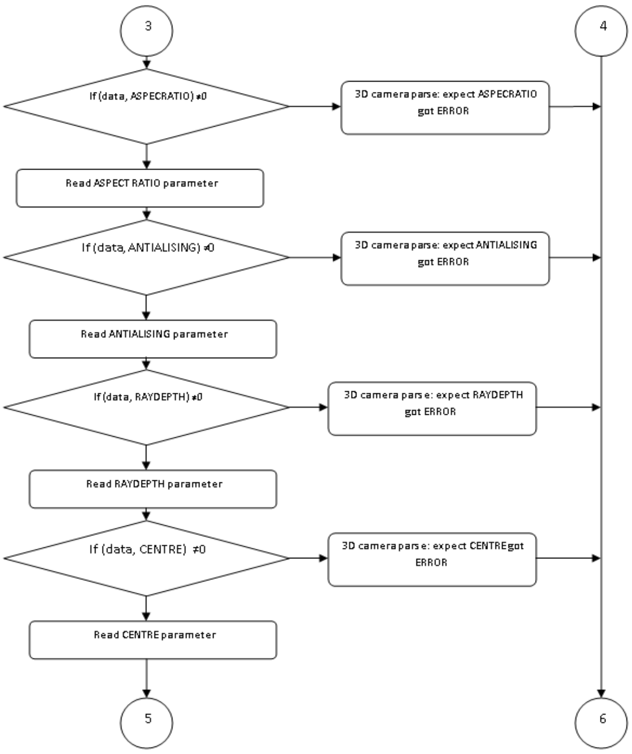
The Figure 4 shows a view windows below show Font, Left, Top, and 3D camera angles onto the model space. The designer can interact with 3D models via the orthographic views and view the model in the 3D window, that displays the current model in a three dimensional perspective.

IV. FLOW CHART OF THE INTEGRAL IMAGES CAMERA PARSER

The flowchart shown in Figure 6, describes the processes of 3D integral imaging camera parser that has been implemented as a part of the 3D integral imaging parser. If the string compares routine returns “0” as a result that means the token is read form the 3D model file format, else the routine returns “1” which means the token is not exist.







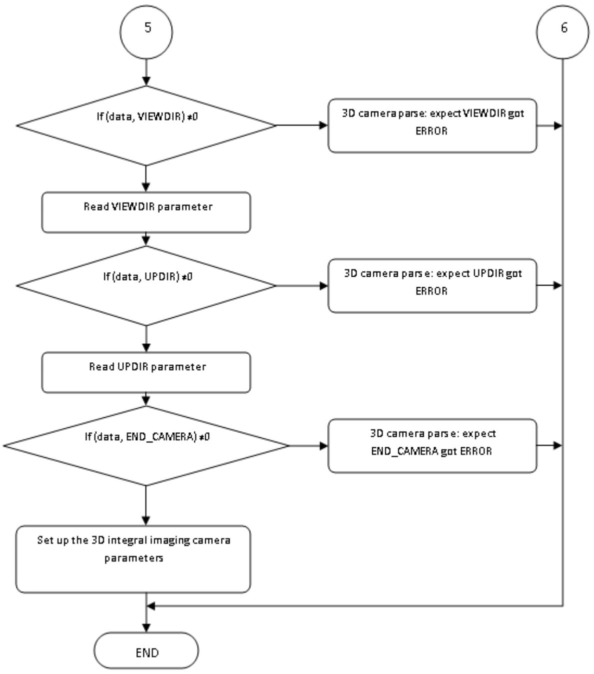


Figure 7: flow chart of 3D integral camera model.

V. EXPERIMENTAL AND RESULT

The results are extremely satisfactory and for the first time it is proved that Ac3D model can be converted to proper file format, parsed and Ac3D integral images (Holoscopic) content can be generated through adapted integral multiprocessor/parallel ray tracer and displayed on commercially available multi-view auto-stereoscopic display. In this paper a unidirectional integral images camera model is adopted see Table I. An example of rendered scenes using the multiprocessor integral imaging ray tracer is shown in figures 8-13.

TABLE I: 3D UNIDIRECTIONAL CAMERA PARAMETERS.

Parameters	Lenticular sheet	
Resolution	512 512	[pixel]
Lens Pitch	2.116667	[mm]
Lens Pixels	8	[pixel]
Aperture Distance	10.0	[mm]
Number of lenses	64	[lens]
Focal length	6.8	[mm]
Ray Depth	2	[integer]

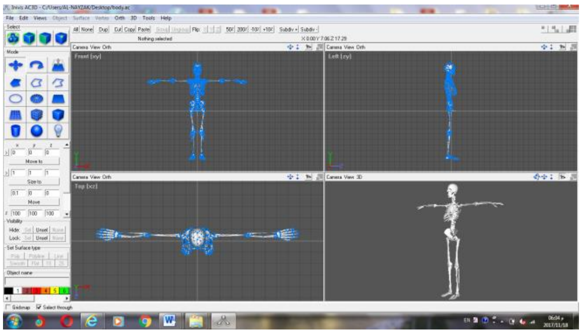
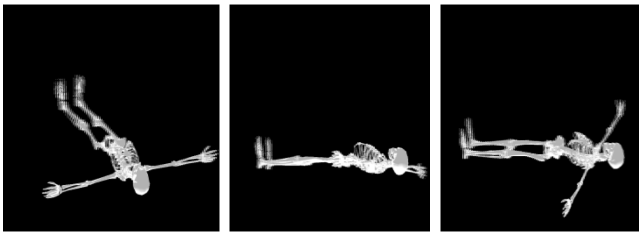


Figure 8: 3D human-body model, created by the Ac3D computer graphics software package.



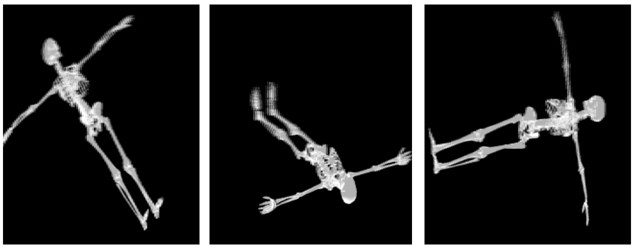


Figure 9: 3D integral image of human body scene frames..

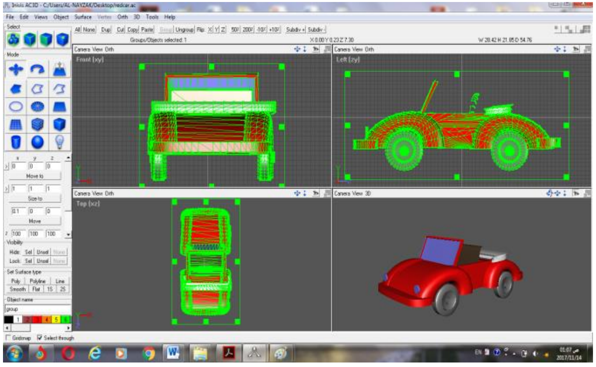


Figure 10: car scene generated by Ac3D Computer Graphics Package .

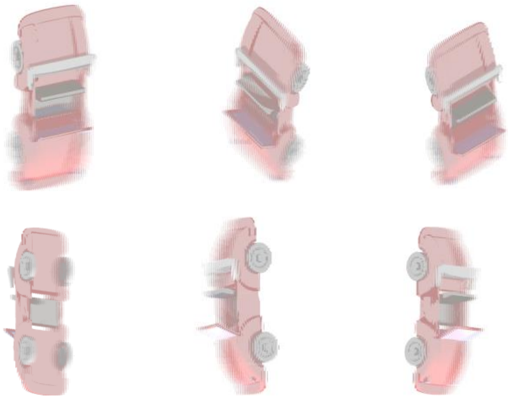


Figure 11: Computer Generated 3D integral images frames from car scene model after converted to 3D car integral images animation.

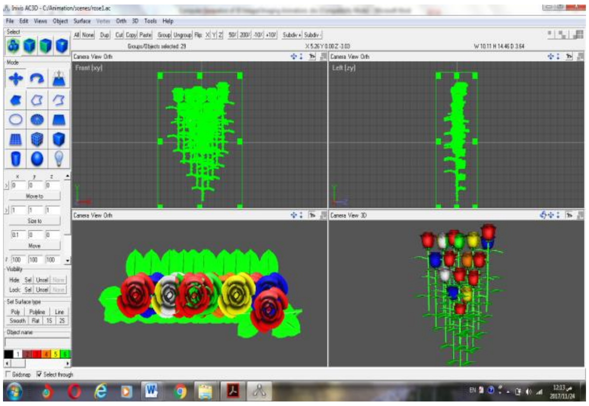


Figure 12: roses scene generated by Ac3D Computer Graphics Package .

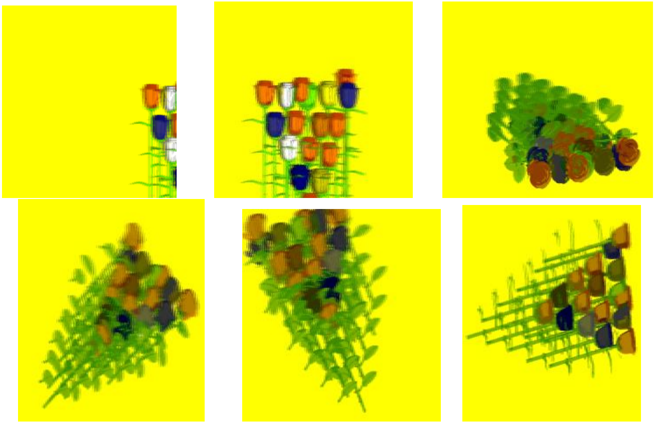


Figure 13: Computer Generated 3D integral images frames from roses scene model.

VI. CONCLUSION

This paper presents new plug-in software tool to allow a computer generation of Ac3D modeling to be displayed on multi-view auto-stereoscopic. In this report we have shown that the 3D Holoscopic content with horizontal parallax can be displayed on commercially available multiview auto-stereoscopic displays. To our knowledge this the first time this has been achieved. For this study the Multiprocessor ray tracing system has been used.

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