ISSN 2229-5518

Maximum Intensity Projection with fast rendering using Point Cloud Data Structure

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Abstract— Maximum intensity projection (MIP) is an important visualization method that has been widely used for the diagnosis of enhanced vessels or bones by rotating the MIP images. With The rapid spread of MDCT (Multi Detector-row Computed Tomography) scanners. This is a volume rendering technique which is used to extract high-intensity structures from volumetric data. MIP works on each pixel the highest data value rendezvous along the matching viewing ray is calculated. MIP is mostly used to extract vascular structures from medical MRI data sets. Example: angiography. Real-time processing and visualization of the 3D image data are the most important requirements in medical imaging. Among various existing 3D visualization methods maximum intensity projection (MIP) is a useful tool to visualize 3D images. However, much-time complexity is a drawback of using the MIP. The time complexity of the MIP depends on the number of data sets of the 3D data. To reduce time complexity, we developed a fast processing Shear-warp algorithm that produces better images in much less time

Index Terms— Maximum Intensity Projection, Angiography, Visualization, Volume Rendering

1 Introduction

In medical imaging we are concentrating to how to depict blood vessels images more accurately and clear. We obtain the volumetric data sets from CT and MRI scanners and after that we extract it to get a vascular structure. We are always using the MRI data sets because it contains less noise data. In angiography, when we are work on MIP then the value of vascular data sets are higher from the value of surrounding data sets [1][2]. To find the maximum data value many methods are used in MIP like Ray casting, splatting and shear-warp all methods are work on each ray and volume instead of processing whole volume like done in direct volume rendering. According to the quality requirements of the image we are using different methods for MIP [3][7].

- *Analytical solution:* Maximum value is to be calculated for each data cell analytically intersected by the ray. Tri-linear polynomial method is used to calculate the maximum value it is accurate method but take so much time [3].
- *Sampling and interpolation:* This method is widely used in ray casting. Tri-linear interpolation method is used to find the maximum ray. The computation depends on the number of interpolations are avoided [3].

□ *Nearest-Neighbour interpolation:* As a name implies that in this method we deal with the closet neighbour data point which has a maximum ray. This is a fast method with combination of discrete ray traversal [3].

Some other recent algorithms which can be used in MIP for speeding up the rendering process:

□ *Ray traversal and interpolation optimization:* As a name implies in this method we optimize the interpolation and ray traversal. In this method we interpolate if the maximum value of data cell is larger than the calculated ray-maximum [2][4]. For ray traversal optimization it uses integer arithmetic and cache-coherent volume storage scheme. Bounded maximum values are also used means data cell who contains lower value from this value are discarded and which contain larger value from it are accepted in final image. For empty spaces it uses distance volume scheme [7].

□ *Using graphics hardware:* In this method they are using the conventional polygon rendering hardware to work on MIP. They are extracting the iso-surface from the data set which has different threshold values. Before the rendering process geometric transformation done in way that the depth of the polygon converted according to its iso-surface. Volume Pro board is latest graphics hardware which produce a medium quality MIP images using shear-warp projection [6].

□ *Splatting and shear warp:* Both techniques have lots of advantages that are why they are used in MIP. In shear-warp we produce a factorization of viewing matrix contains the 3-d volume slice data to shear it and warp it to produce a final image [6]. Splatting works on special function called Footprint that spans many pixels in screen space, and always represented by Gaussian function. We called it splatting because the voxels spread out over the screen plane by the distribution function, just like a snowball on the surface [9].

After discussing the MIP algorithms we can say that MIP images contain less shading, depth and occlusion information. MIP work with two variant Depth shading MIP and Local MIP. Depth shading MIP gives better spatial relationship between objects low performance for highly coupled structures. Local MIP used a user defined threshold value for a first pixel value to give an image better contrast effect. In next section 2 we are discussing about preprocessing of data sets. Further I discuss about volume

ISSN 2229-5518

storage scheme that I am used for proposed algorithm. In section 3 we are discussed about proposed algorithm.

2. PRE-PROCESSING AND DATA STORAGE

A .Motivation

Although after studying and reading about MIP I always think that how it is works and how it is used in medical industry so I study about MIP through papers and research articles and I conclude that MIP is a future of Medical industry it is a fast growing method used in medical industry. It gives us lots of information about our body cells lots of big diseases are discovered by help MIP. Researchers are concentrating on the time complexity and computation of MIP. MIP works on volumetric data and to store it we need a good 3-d data structure and good processing algorithm, which works on less time complexity and gives us better image quality because in Medical imaging image quality is most important then time.

B. Voxels Removal

Before making volume data sets we are excluding the Voxels, which contains less important data like low valued background noise to optimize the ray traversal and rendering process. For this we are using two algorithms which are working on Voxels and make much optimized volumetric data sets. These two methods are as follows:

1) Neighbourhood-based elimination: In this type of elimination we remove Voxels by comparing the frequencies of neighbourhood Voxels. This method works as a checker that checks the maximum value along the sequential Voxels rays are traversed in a sequential way if the frequency of Voxels is larger than from its neighbourhood then it's the set of volumetric data otherwise its discarded.

2) Shadow-Sweep elimination: In this method we shadowed all the Voxels and each Voxels have a maximum ray when the ray are passing on the Voxels we check the maximum value by comparing the arrival frequency from the maximum value. This is done in a forward way. The method works in two phases in first phase we process in forward direction and remove the Voxels and in second phase we process in backward direction.

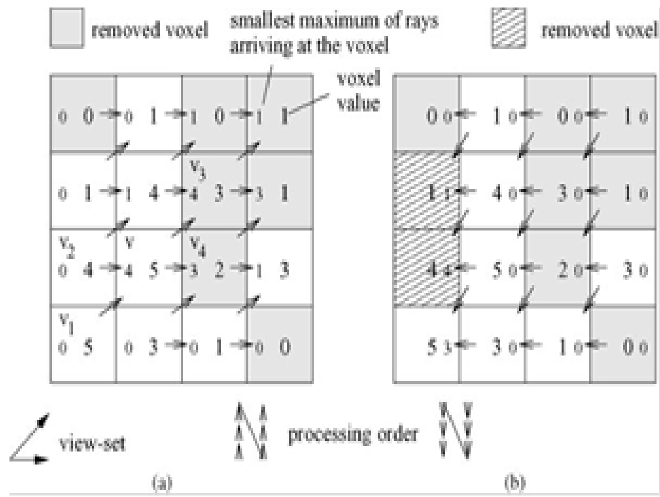

Figure 1: Shadow voxel sweep Process (a) Processing in Forward Direction (b) Processing in Backward Direction

C. Data Storage

After getting volume data sets from above discussed methods the big issue is how to store it in memory more efficiently. 3-d array is mostly used data structure to store volume data sets but in my algorithm I worked with Point Cloud data structure.

1) Point Cloud: In a point cloud representation data is represented as a cloud of spatial points. This is the simplest representation of spatial data. Each point is stored in an individual object. In particular, connectivity information is not stored. 3D scanning is an example which generates such a point cloud. In this case a laser range scanner is sampling the surface of an object. For each sample point the distance between the scanner and the surface point is retrieved. By knowing the position of the scanner in respect to the object as well as the accurate direction of the ray, a calculated 3D point is based on this distance. The scans from different viewpoints are finally registered and combined to a single point cloud which represents the whole object. Figure 1 shows an example of such a point cloud.

ISSN 2229-5518

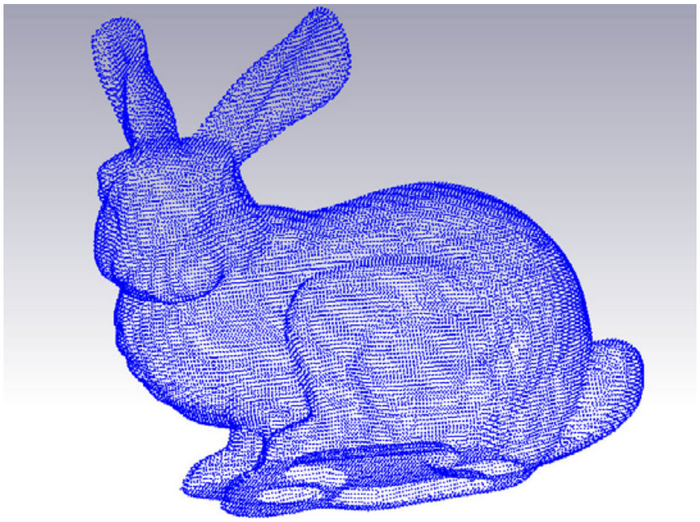

Figure: 2 Point Cloud structure of image generated by 3-d scanner

In point cloud architecture we make cloud object which is a collection of points.

Cloud Object= Collection of Points.

Point= Spatial Coordinate (x, y, z).

D. Rendering

The rendering process for points is very simple. Each point is simple projected onto the corresponding pixel on the screen. To represent closed surfaces it is necessary to have enough points (>1 point per pixel). The z-buffer can be used to get the correct occlusion of the points. Due to the increasing power of graphics hardware the complexity of models has rapidly increased from last few years. We discussed earlier that polygon rendering is used in graphics hardware a single polygon representation is much smaller from the area of point pixels. In such a case it is more efficient to represent the model with a point cloud in respect to memory consumption.. Thus we can say that Point Cloud is often used to represent the complex models.

E. Advantages of Point Cloud

There are various advantages in favours of MIP by using Point Cloud structure, they are pointed as follows:

☐ Fast and easy rendering due to using points we are work on each point no need to access one point at time each object contains a list of points after initialization of object we can use these list for rendering.

☐This is Possible that when we use Point cloud the exact representation of image is done in favours of medical imaging. Because for each pixel one point is appointed so we get a better image quality.

☐ Easy transformation of points into objects are done means we easily transform the points of one object to another object

3. Proposed Algorithm

Voxels of volumetric data set are processed in arbitrary spatial order defined within the Point Cloud object. The projection of all points is to be calculated and stored into a Point cloud object. I make a three objects for three axis points x, y, z all objects are stored in image buffer. The rendering loop I discussed here is as follows:

```
Xobject=make_object(viewmatrix,volumesize_x);
    Do the same for yObj, zObj;
    For intensity=0 to max do
      gray = function[intensity];
       if (gray!=BLACK)
        for index=first[intensity] to
        first[intensity+1]-1 do
     Pointpos=Point Cloud Object [index];
screen[xObj[Pointpos.x]+yObj[Pointpos.y]+zObj[Pointpo
s.z]]=gray;
```

The proposed algorithm is also a trade of speed and quality. But I surely say that this algorithm is fulfilling it both speed and quality. Works on object oriented technique algorithm I able to produce better results in time with best compilation rate. The proposed algorithm works in all variant of MIP Like window, LMIP and Depth shaded MIP.

4. Result and Analysis

The volume storage technique and proposed algorithm is coded into a java. The rendering time in ms for three variant of MIP is show in table1. The algorithm gains a good speed in rendering process and produces a better image. Figure 3 show the image I got after working on Point Cloud approach mix with the object base shear-warp projection method.

ISSN 2229-5518

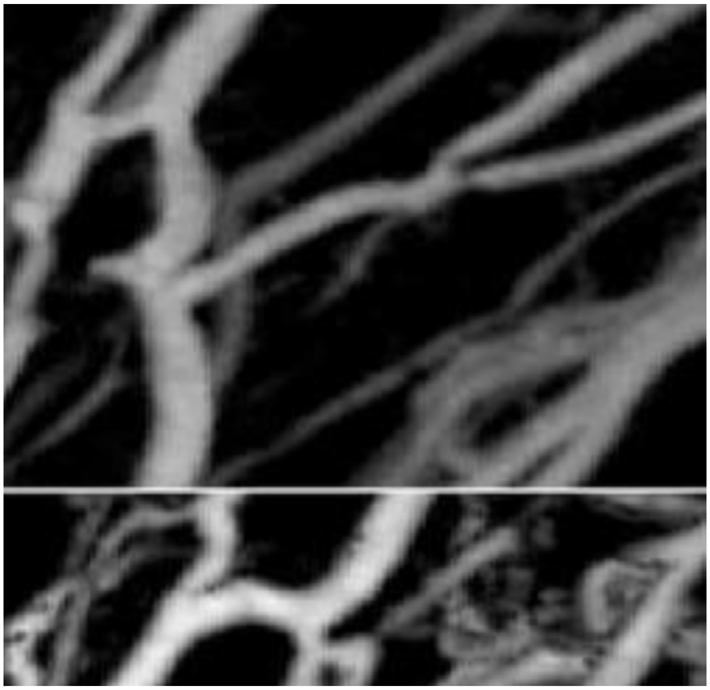

Fig 3: MIP of hands vessels using proposed algorithm showing all three varients of MIP

Table 1: Rendering Time analysis

Data Set	MIP (ms)	Win-dow(ms)	LMIP(ms)	Depth MIP(ms)
2562*68	150/80	25/20	<305/180	209/118
2562*75	173/130	50/45	<288/198	224/146
2562*85	189/160	10/8	<455/370	338/267
2562*96	224/200	23/22	<500/300	275/230

5. CONCLUSIONS

We presented a new MIP algorithm which produces real time images in quick time. Algorithm achieves a great rendering speed with a better image quality, works with all three variant of MIP and gives us good results. Algorithm has less time complexity. Shear-warp Projection is used to produce a better image quality.

ACKNOWLEDGEMENT

I take this opportunity to express my profound gratitude and deep regards to my guide **Mr. Deepak Gupta** for his privileged guidance, checking and constant inspiration throughout the course of this work . The blessing, help and guidance given by him time to time shall carry me a long way in the journey of life. I also take this opportunity to express a deep sense of appreciation to our dissertation coordinator **Ms. Shikha Gupta** for his genial support, valuable information and guidance, which helped me to complete this task through various stages.

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