Treecube+3D-ViSOM: Combinational Visualization Tool for Browsing 3D Multimedia Data

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Abstract

This paper proposes a new visualization tool for browsing 3D multimedia data. This is realized as a combinational visualization tool of Treecube and 3D-ViSOM which are both proposed by the same research group of the authors. Treecube is a visualization tool for hierarchical information developed as a 3D extension from a 2D visualization tool, Treemap proposed by Ben Shneiderman, et. al. in 1992. Treecube is useful for browsing 3D multimedia data stored in a file system because the file system has a hierarchical structure. However, if many data exist in one directory, it is not easy for the user to find his/her required data from it. On the other hand, 3D-ViSOM is a 3D-SOM (Self Organizing Map) based visualization tool for browsing 3D multimedia data. Using the 3D-SOM layout, similar feature data are located in the same area and it is easy for the user to find his/her required data by the browsing. Since 3D-ViSOM can solve the problem Treecube has, the authors propose a combinational visualization tool of Treecube and 3D-ViSOM in this paper.

Keywords: Visualization, Browser, Multimedia, 3D-SOM, Treecube, 3D-ViSOM

1. Introduction

In this paper, we propose a new visualization tool for browsing 3D multimedia data, which is realized as a combinational visualization tool of *Treecube* [1,2] and *3D-ViSOM* [3]. Recent advances in hardware technologies have made it possible to create 3D images in real time even using a standard PC and 3D CG has become very common in game and movie industries. As a result, many polygonal models and motion data have been created and stored. 3D CG creators and designers need any tools that help them to easily find their required polygonal models and motion data. This fact motivated us to propose a new visualization tool called *Treecube* for browsing 3D multimedia data originally stored in a file system.

Our *Treecube* is derived from a 2D visualization tool called *Treemap* [4] proposed by Ben Shneiderman, et al in 1992. *Treemap* visualizes hierarchical information. Generally, hierarchical information is represented as a tree structure. *Treemap* hierarchically lays out each node as a bounding box, whose size is the same as the specific weight or attribute value given to the node. Practically, a lot of tree-structured data exist and the size of such data is going to be greater and greater. Such a huge size of tree-structured data needs an efficient visualization tool. As a result, *Treemap* has become one of the very useful visualization tools. However, layout algorithms *Treemap* has are all 2D. Therefore, we have developed a 3D visualization tool, *Treecube* by extending the 2D layout algorithms of *Treemap*. This tool is useful for browsing 3D multimedia data, i.e., 2D images, 3D polygonal models, motion data etc., originally stored in a file system because it can automatically lay out them in a specified, restricted 3D space. However, if there are many 3D multimedia data in one directory, it is difficult for the user to find his/her required data efficiently even using *Treecube*. So, in this paper, we propose a combinational visualization tool of *Treecube* and *3D-ViSOM* because *3D-ViSOM* can solve the above problem of *Treecube*.

Our *3D-ViSOM* is a 3D-SOM (Self Organizing Map) based visualization tool for browsing 3D multimedia data. Using the 3D-SOM layout, similar feature data are located in the same area and it becomes easy for the user to find his/her required data by the browsing. Fortunately, both visualization tools *Treecube* and *3D-ViSOM* are realized using *IntelligentBox* [5], which is a component-based 3D graphics software development system and it is easy to combine them. Hence we developed a combinational visualization tool of *Treecube* and *3D-ViSM*. In this paper, we show its usefulness as a browser for 3D multimedia data.

The remainder of this paper is organized as follows: Section 2 introduces our *Treecube* visualization tool. Especially we explain its layout algorithms and interfaces. Section 3 introduces our *3D-ViSOM* visualization tool. Especially, we explain feature vectors for each type of 3D multimedia data input for 3D-SOM. Section 4 shows our

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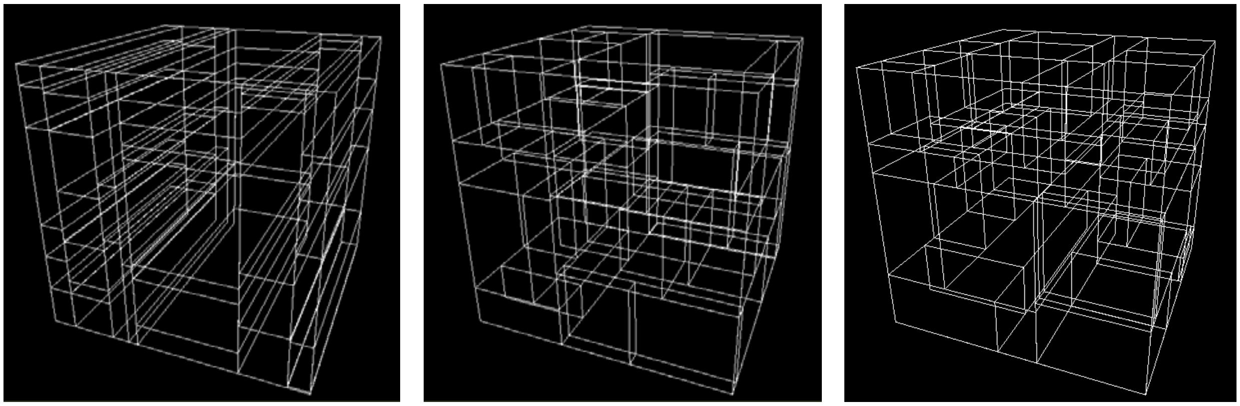


Fig. 1: *Treecube* layout algorithms: slice-and-dice (left), ordered (center) and strip *Treecube* (right).

proposed combinational visualization tool of *Treecube* and *3D-ViSOM* for browsing 3D multimedia data. Finally Section 5 concludes the paper.

2. *Treecube* Visualization Tool

For *Treemap*, besides the original layout algorithm called slice-and-dice, there are several extentions, i.e., squarified *Treemap* [6], ordered *Treemap* [7] and strip *Treemap* [8]. Moreover, quantum *Treemap* [8] is a quantization version of these extensions. We have extended 2D versions of layout algorithms of slice-and-dice, ordered, strip and quantum *Treemap* to their 3D counterparts. In this section, we explain the outline of those *Treecube* layout algorithms. For the details of *Treecube* layout algorithms, see the paper [1].

2.1 Slice-and-dice *Treecube*

The slice-and-dice *Treecube* algorithm creates a layout where the bounding box of each item (node/leaf) is located in the simple linear order. The algorithm divides a rectangular solid along x, y and z direction and recursively. Figure 1 (left) shows a layout example generated by the slice-and-dice *Treecube* algorithm. The system visualizes the file and subdirectory structure of a certain directory of a file system. Most bounding boxes shown in the figure are so thin that it is difficult to put 3D multimedia objects in them. This is the same negative feature as that of the slice-and-dice *Treemap* algorithm. The aspect ratio of each bounding box should be close to one for the visual efficiency.

2.2 Ordered *Treecube*

The ordered *Treecube* algorithm divides a rectangular solid based on a concept of "pivot". The pivot node is selected from a node list by a certain criteria. And the remaining nodes are laid out in order to make the pivot into a cubic shape. Figure 1 (center) shows another screen shot of the layout generated using the ordered *Treecube* algorithm. Although there are still some thin bounding boxes but most bounding boxes have a near cubic shape in comparison with those of Figure 1 (left). The ordered *Treecube* algorithm is apt to generate lower aspect ratio-bounding boxes rather than the slice-and-dice *Treecube* algorithm. This means that the ordered *Treecube* algorithm is suitable for the visualization of 3D multimedia data rather than the slice-and-dice *Treecube* algorithm.

2.3 Strip *Treecube*

The strip *Treecube* algorithm once divides a given rectangular solid into a set of flat solids called "slice", and moreover divides each slice into a set of slender solids called "strip". Each node of a node list is put in the corresponding of strips and its shape is varied into a cubic shape with keeping the order of a hierarchical structure. In Figure 1 (right), the strip *Treecube* algorithm generates the almost same number of lower aspect ratio-bounding boxes as that of the ordered *Treecube* algorithm. The strip *Treecube* algorithm arranges given data simply in a certain direction, so the order of data is almost preserved in comparison with ordered *Treecube* layout.

2.4 Quantum *Treecube* algorithms

As mentioned above, bounding boxes generated by the *Treecube* layout algorithms have arbitrary aspect ratios. As extensions of *Treemaps*, quantum *Treemaps* [8] were proposed to visualize fixed size objects such as 2D images grouped together into semantic categories. Similarly, we extended our *Treecubes* to lay out categorized 3D objects, i.e., polygonal models, motion data and 2D images. Our quantum *Treecube* algorithm generates the layout of multiple fixed size 3D objects. For this, it is necessary to change the size of a rectangular solid in order to make its width, height and depth be integer multiples of the given 3D object size. In other words, a bounding box has a grid of cells in the inside of itself, in each of which each fixed size 3D object is located. Even if there are empty cells in a box, all objects can be laid out sufficiently in the box. However, it may occur undesirably that the volume of a box quite differs from the total amount of the volumes of objects laid out in the box. For instance, when you want to lay out 50 objects that have $(1 \times 1 \times 1)$ size into a bounding box whose size is $(100 \times 100 \times 100)$, the box resized becomes completely different from the original shape. For avoiding this problem, we use a relative ratio of the width, height and depth of a given rectangular solid instead of their absolute values. Then it is possible to keep out from the drastic deformation of a bounding box by making the number of objects laid out along each x-, y- and z-direction match to the size specified by the user.

2.5 Browsing 3D multimedia data by *Treecube*

We developed an actual visualization tool for browsing 3D multimedia data, e.g., 2D images, 3D polygonal models, motion data and so on. The *Treecube* algorithms demonstrated in Figure 1 automatically lay out 3D objects into a specific, restricted 3D area. Figure 2 shows the screen shot of an actual visualization tool that displays 3D multimedia data laid out by the quantum strip *Treecube* algorithm. Actually this visualization tool is developed using *IntelligentBox* [5]. As *IntelligentBox* is a component ware and provides various functionalities as software components called *boxes*, a file selection functionality for choosing a directory of a file system and an input functionality for entering several parameters necessary for *Treecube* layout algorithms are implemented as composite *boxes*. We implemented interactive interfaces and introduced them into the visualization tool for browsing 3D multimedia objects and finding required objects efficiently. Next sub-section introduces such interfaces and explains their functionalities.

2.6 Interactive Interfaces of *Treecube*

This sub-section treats interfaces implemented to enhance the ability of *Treecube* as an interactive visualization tool for 3D multimedia data.

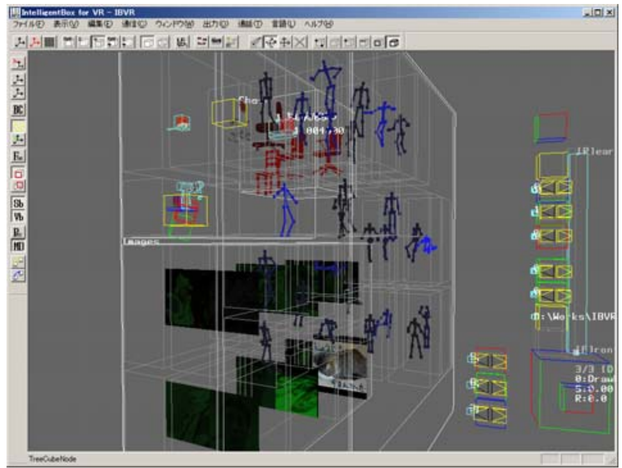
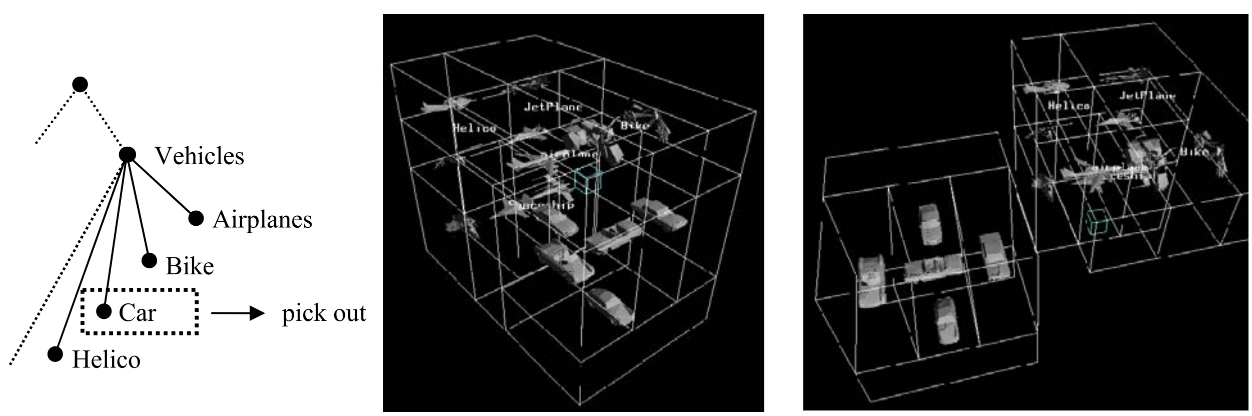


Fig. 2: Quantum strip *Treecube* algorithm.

2.6.1 Interactive manipulations

There are standard operations for the translation and rotation of an eye position and for the zoom in/out. Using these operations, it is possible to rotate an entire *Treecube* and to make it larger/smaller interactively.

There are some particular operations as follows. Figure 3 (a) and (b) show hierarchical information example and its *Treecube* layout respectively. When the user wants to rotate a leaf node object in the hierarchical information, e.g., one car model, the mouse click and drag operation on that object enables it. When the user wants to extract an intermediate node in the hierarchical information, e.g., "Car" group, the mouse click operation on that box enables it as shown in Figure 3 (C). It will become easier to see objects inside of that box. Moreover, if the user selects and clicks on a bounding box with pushing a certain key, the system will regenerate a *Treecube* layout whose root is the selected bounding box. Reversely, if the user clicks on the same bounding box again with pushing the same key, the system will display the previous layout. As shown in Figure 4, we can browse objects in a



(a) Hierarchical information example (b) Layout of "Vehicles" (c) Extraction of "Car" group

Fig. 3: Example of extraction operation.

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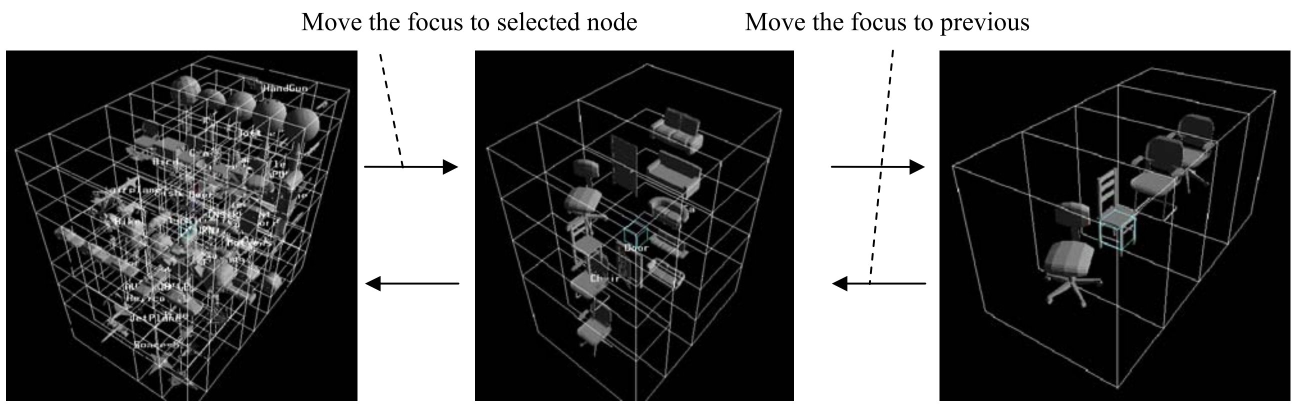
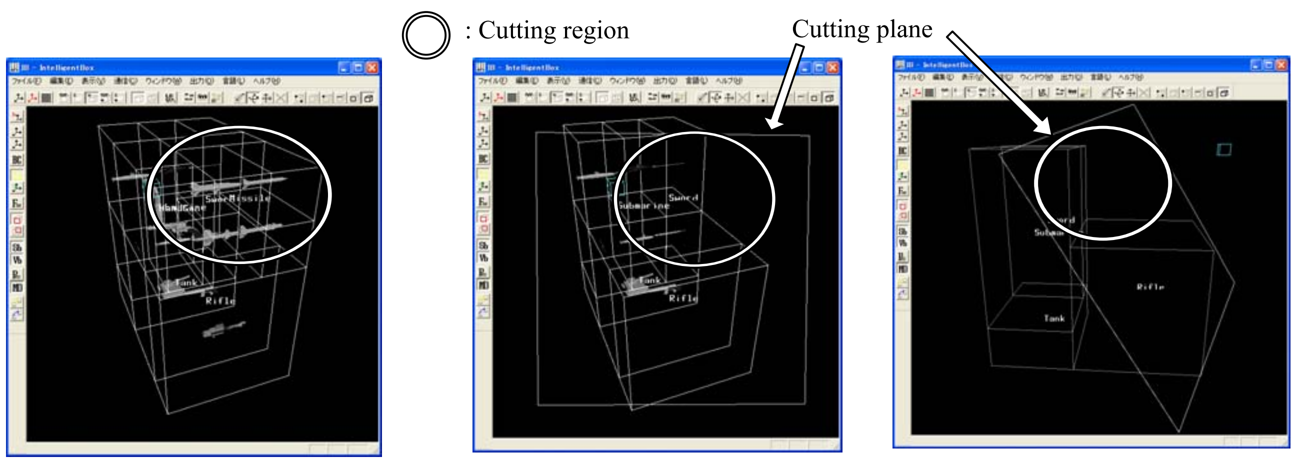


Fig. 4: Backward/forward operations for browsing hierarchical information.



(a) Without a cutting plane (b) With a cutting plane

Fig. 5: Control the visibility of 3D objects using a cutting plane.

hierarchical structure of 3D multimedia data by the operations like the backward/forward of Internet browser.

2.6.2 Cutting plane interface

Treecube is a 3D visualization tool and it has the occlusion problem. In our *Treecube*, many leaf node objects are put inside of a restricted 3D rectangular solid space and it is hard to see the objects behind other objects. To solve this problem, we introduced a particular interface called "cutting plane". As shown in Figure 5, the objects before a cutting plane are automatically hidden by the system, and then the objects behind the plane can be seen easily. Its manipulation is very simple. The user only changes the distance of a cutting plane from the eye position because the plane is automatically directed towards the eye point. The user can also change the visibility of a cutting plane by a mouse-click operation on the plane.

As explained in this section, our Treecube visualization tool is useful for browsing 3D multimedia data. However, as previously explained, if there are too many data in one directory of a file system, it is hard for the user to find his/her required data even using *Treecube*. To solve this problem, another visualization tool called *3D-ViSOM* is available and them we combined its functionality into *Treecube* visualization tool. In the next section, we introduce our *3D-ViSOM* visualization tool.

3. *3D-ViSOM* Visualization Tool

SOM proposed by T. Kohonen [9] is one of the neural network algorithms. Usually SOM maps high dimensional data records that have more than two attributes onto a 2-dimensional space by analyzing them using their feature vectors. This is called 2D-SOM. In addition to 2D-SOM, there are 1D-SOM and 3D-SOM can perform 1D and 3D mapping respectively. We consider that it is natural to use 3D-SOM for the visualization of 3D multimedia data and we developed 3D-SOM based visualization tool using *IntelligentBox*. In the following sub-sections, we explain which features of 3D multimedia data, i.e., polygonal models, motions and 2D images, are used for the 3D-SOM layout.

3.1 Feature vector for polygonal model data

We chose shape distribution [10] as the feature vector of polygonal models for the 3D-SOM layout. This information is originally proposed to be used as similarity

Fig. 6: 3D-SOM layouts of polygonal models (a), motion data (b) and 2D image data (c) respectively.

measure for the polygonal model search. Shape distribution data is obtained by the sampling of distances between two random points on the surface of a polygonal model. This data is represented as one histogram and we use this histogram as the feature vector of the polygonal model. Figure 6 (a) shows a 3D visualization example of our polygonal model database including 280 models categorized into 14 classes, i.e., Robot, Human, Chair, Sofa, Table, Plant, Door, Car, Glass, Fruit, Pot, Tire, Fish and Head. Similar shaped models are located closely to each other so it is easy to find required polygonal models associatively.

3.2 Feature vector for motion data

We chose feature information obtained by the space division quantization method [11] used as similarity measure for the motion data search. This information means how long each joint exists in each divided region of a 3D space in a complete motion. See the paper [11] for its detail. This information is represented as one set of histograms and we use this set as the feature vector of the motion. Figure 6 (b) shows a 3D visualization example of our motion database including 61 motions categorized into 7 classes, i.e., Kick, Sit, Walk, Throw, Jump, Tumble and Arise. In this case, there is another particular component of *IntelligentBox* called *MotionBox* that has functionalities to read a motion file and to display it as its skeleton animation. In the same way as the case of polygonal model data visualization, similar motions are located closely to each other so it is possible to find required motions visually and interactively.

3.3 Feature vector for 2D image data

As for 2D images, we use Hue component of HSV color as the feature information. The feature vector can be obtained as the probability distribution of Hue intensities over a whole image. Figure 6 (c) shows a 3D layout example of our 2D image database including 164 images categorized into 10 classes, i.e., Cat, Dog, Flower, Airplane, Mountain, Sky, Water, Space, Squirrel and Animal.

3.4 Hierarchical browsing of 3D multimedia data

If there are a huge number of data, it is impossible to display and browse them. To deal with this problem, *3D-ViSOM* system employs a hierarchical display mechanism.

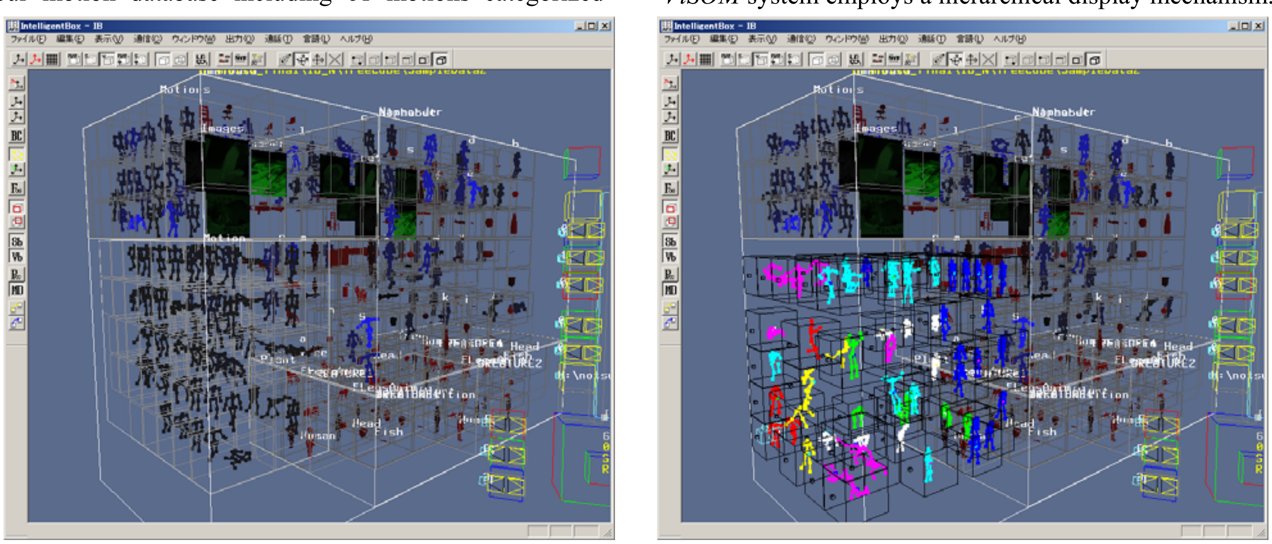


Fig. 7: (a) *Treecube* visualization of many 3D multimedia data, and (b) *3D-ViSOM* layout of motion data.

If there are too many data in a small region to see and to access a target object, the system displays only one average, center position data as the representative of those data. When the user selects the average data, the system displays all of the data included in that region by the 3D-SOM layout.

4. *Treecube+3D-ViSOM* Visualization Tool

Finally, this section shows *Treecube+3D-ViSOM* visualization tool. Figure 7 (a) show an actual *Treecube* visualization tool for displaying many 3D multimedia data stored in a file system. If there are too many data in one directory, the user can not find his/her required data. For example, the left lower part of *Treecube* in Figure 7 (a) includes many motion data existing in one directory. In the case like this, using *3D-ViSOM*, the user can obtain 3D-SOM layout of those motion data as shown in Figure 7 (b). Similar motion data come to be located in the same area so that the user can find his/her required motion data more easily. As explained in previous sections, *Treecube* and *3D-ViSOM* are both one particular component of *IntelligentBox* and it is possible to combine them together easily. By combining them, our *Treecube* comes to have another advantage of 3D-SOM based visualization tool and it became more and more useful for browsing 3D multimedia data.

5. Concluding Remarks

In this paper, we proposed a new visualization tool for browsing 3D multimedia data. This tool is realized by combining our already proposed two visualization tools, *Treecube* and *3D-ViSOM*. Originally these visualization tools are developed as individual components of *IntelligentBox* and it is possible to combine them easily so we developed a combined tool of them. The *Treecube* algorithms automatically lay out 3D objects, which are originally stored in a file system, in a specified, restricted 3D space. This paper explained these layout algorithms of *Treecube* and showed that this tool is useful for browsing 3D multimedia data. However, if there are too many data in one directory, even using *Treecube*, it is difficult for the user to find his/her required data rapidly. This problem of *Treecube* was possible to be compensated by using 3D-SOM layout mechanism of *3D-ViSOM*. So, we introduced *3D-ViSOM* visualization mechanism into *Treecube* visualization tool. As a result, our *Treecube* combined with *3D-ViSOM* became more powerful visualization tool for browsing 3D multimedia data.

As future works, we have to introduce more practical interfaces into *Treecub+3D-ViSOM* visualization tool for more efficient browsing of 3D multimedia data. We also have to check the usefulness of our visualization tool by consulting actual users who use it.

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