Vol. 90 No. 2 pp. 771–772 ACTA GEOLOGICA SINICA (English Edition) Apr. 2016

Research Advances

Three-Dimensional Reconstruction of Fossil Insects within Their Ecosystems

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Objective

This work is designed to improve the quality, visual effect and production efficiency of ecological reconstruction of fossil insects by using various three-dimensional software and exploring helpful methodologies and techniques.

Methods

We designed corresponding production methods according to the morphological characters of various fossil insects and then used 3D software to reconstruct the drawings. The production methods are summarized as follows.

Polygon modeling was used to make base mesh in the Autodesk Maya. We gradually subdivided it to obtain a high-accuracy 3D model, for example, by adding edges and merging points. When a polygon model was finally finished, we unwrapped UV (U coordinate and V coordinate) properly. High-quality UV mapping will lay a foundation for further steps. According to the pose of insects, we set up bones and controllers for the model.

After that, the model needs to be exported to ZBrush 3.0 to add more details. Details on the model will be turned into normal mapping and displacement mapping to play a role in the rendering. Some color mappings were conducted by graphic design software, some were completed in ZBrush. Finally, these images were often polished up in AdobePhotoshop and other plug-ins. The color of insects was reflected by the cooperation of these mappings.

There are two ways of creating a 3D scene for the ecological environment. One way is to create a small scene in Maya, and the other is to create a large one in VueXstream. As to the textures, we link diffuse, specular, bump, displacement (when necessary) and reflection maps together, producing a complicated material node, which is an algorithm to simulate the physics of how light behaves when it strikes a surface. The setae and bristles of insects can be created by Fur of Maya or plug-ins such as Shave and a Haircut.

We used the render layers to adjust each element conveniently. We imported all layers, including all color layers, specular layers, shadowlayers, reflection layers, ambient occlusion layer, mask layer and hair layers, into Photoshop for further image processing.

Results

The afore-mentioned methodologies and techniques are powerful and effective in improving the quality, visual effect and reconstruction efficiency of fossil insects, hence addressing the issues of low image resolution and difficulty in revision for the traditional reconstruction drawings. By using advanced technology, we have produced 3D reconstructions of many newly described fossil insects and their associated ecosystems with a good visual effect to highlight accurate structural features, realistic properties of materials and the correct lighting and shadows (Fig. 1). Compared to the traditional reconstruction drawings, these visual arts present information more vividly and accurately.

Besides, the pose of 3-D model can be changed by bones and controllers in the 3D space and the 3D scene of the ecological environment can be modified independently. So the 3D reconstruction drawings are easy to revise and update based on findings of new material and/or new development of scientific research.

Furthermore, the resulting artwork provide a magnificent way to gain popular science attention from the general public while motivating young audience to develop interest in natural science.

Conclusion

The optimized combinations of 3D techniques are

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Fig. 1. Three-dimensional ecological reconstructions for fossil insects of (a), *Acephialtitia colossa* Li, Shih, Rasnitsyn & Ren, 2015; (b), *Juracimbrophlebia ginkgofolia* Wang, Labandeira, Shih & Ren, 2012; (c), *Bellinympha filicifolia* Wang, Ren, Liu & Engel, 2010; (d), *Palaeoxenus sinensis* Chang, Muona & Teräväinen, 2015; (e), *Epicharmeropsis hexavenulosus* Huang, Ren & Shih, 2007; (f), *Prolyda dimida* sp. nov.

summed up by the characteristics of different insect groups, which will improve the rendering efficiency. Our approach by integrating artistic techniques and scientific understanding of paleonentomology has improved the level of fossil insect reconstructions and provided better service to the scientific work and visual enjoyment. In addition, these exquisite 3D reconstruction drawings will become a bridge between scientific research and popular science to gain attention from the general public while motivating young audience to develop interest in natural science.

Acknowledgements

This study is supported by the National Basic Research Program of China (973 Program; grant No. 2012CB821906), the National Natural Science Foundation of China (grants No. 31230065 and 41272006), Great Wall Scholar and Key Project of Beijing Municipal Commission of Education Project (grant No. KZ201310028033) and the Program for Changjiang Scholars and Innovative Research Team in University (grant No. IRT13081).