Construction of 3D Virtual Reality Insect Model Based on Ips typographus L

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Abstract. The development and application of the digital model database of insects has an academic and also practical value. To find a proper way of building 3D Virtual Reality Insect Model, we briefly studied the application in different fields of digital modeling technology and points out that artificial modeling technology is suitable for the 3D virtual insect data model. We also discuss the pipeline of making digital model database of insects and take an example of constructing digital model on bark beetle, Ips typographus L.

Keywords: 3D Virtual Insect Data Model, High-poly Animated Insect Model, Virtual Reality Database

1. Introduction

3D virtual insect data model could be obtained the 3D data, save body posture and structure information of insects. The digital model are benefit to the accumulation of human civilization, promote the development of entomology and other disciplines. Once established high-poly animated model of insect which could digitally save the insect objective data, not only has the great significance in insect taxonomy, but also play an important such as pest control, insect ecology, insect taxonomy, its behavior so on and so forth. It also has huge commercial value of the services for filming and VFX making also include virtual reality in fields[1] and could be used to build the digital museum, specimens surveying and mapping, specimens protection.

Digital insect database could made of three sections which could be used in three fields: IBM (image based modeling) [2-3], digital three-dimensional laser-scanning[4] and shape from interaction[5].

2. Materials and Methods

2.1. Materials and Tools

Bark beetle specimens collected from May 2013 in Heng Shan forest Centre, Chang bai Korean autonomous county in Jilin province. Adults of Ips typographus L. are preserved in 75% ethanol after collected.
The observation and video using SZX16 stereo microscope and JMS - 6510 scanning electron microscope.

The main modeling software is Autodesk Maya2014 which could be useful in most situation such as topology, skin binding, map checking etc. We also use Pixologic’s ZBrush4 to capture and projecting tiny surface details and also use that to fix digital noise. The xNormal3.18.4 which is for the multi-map baking such as normal, specular, base color so on and so forth.

2.2. Methods

Because bark beetle’s body is a little bit small (<0.5 mm) and it was difficult to see morphological characteristics with naked eye. We choose microscopic photograph to get some reference at early stage and then three-dimensional scanning to generate low resolution model and manually shifted model’s mesh topology. After that we do the texture work to give it color, specular, roughness and normal information and then manually generated model of grid topology for animation.

This method is suitable for observing ‘medium’ local details on the specimen’s body. Because of the tiny sections it was hard to observe details of the bark beetle and if we decided to cut the body into very smaller pieces for observing, it should cause sample damaged. Obviously, in order to observe the sample under the electron microscope, it is inevitable to cut the sample, but it cannot be excessively cut. So we decided to cut it manually in the form of insect anatomy such as maxilla, labium and mandible, elytra and membranous wings connected to tergum, pronotum and 1 ~ 8 sterna, etc. After that We take photo reference of the cut samples and using the ‘Image Digital Imaging System (IDIS)’ to build pictures for those cutting tiny parts. These composite images have several uses: providing detailed reference in the process of model making, providing color information for making textures, removing the color information of the image and generating height map to provide displacement map information.

3. Results and Analysis

It’s about fifty images of digital microscope used to construct *Ips typographus* L. 3D virtual insect data and twenty sketches by hand-drawing at early stage. And then we worked with this pipeline: low-polygonal mesh (very rough sketch); mid-polygonal mesh (draft); reconstructing topology (for animation); high-polygonal mesh formal production; convert high–polygonal mesh to low-polygonal mesh (formal).

3.1. High-poly Model Construction of *Ips typographus* L.

We used IBM to create the base low mesh in Autodesk’s 123DCatch which could generate triangulable-mounted model. The polygonal sketch model of the bark beetle could be used to increase the details and more average and it should carry out automatic calculation to fill the hole and grid reconstruction by the engraving software. We used Cat-mull and Clark algorithm to subdivide the low-poly model three or four times using ZBrush. This would get more polygonal parts details to work with include antenna, compound eye, head, prothorax, abdomen, elytra and legs the more polygons generated, the more details obtained.

We using displacement map to turn the grayscale image which has mentioned before it came from microscope photo compositing and turn to grey scale to give the 3D model surface more detail. We project the prepared information of pictures to the digital model directly saving a lot of time. The method reference for modeling that applied the 3D-reconstruction to paleontology to increase the details [6].

Hairs and its texture of *Ips typographus* L. was generated on the low-poly model after topology. In order to ensure high simulation of the digital model, the hair and alveolus parts of the specimen body added to the model after independent production. The wax material at the elytra apices also be disposed in the depolyment of material. The virtual data model of *Ips typographus* L. was shown in figure 1~3.
3.2. Analysis of Animated Motion Mode on Ips typographus L.

The entomic motion mode summed up as six legs and could be divided into two groups. When it crept forward every step, the body supported by using one group, another group of legs raised slightly and out of the ground to move forward. Thus, the beetle’s body is always been supported by the imaginary triangle points, when three legs in triangular group were raised, another three legs of triangular stay where they should be and hold the body. Centre of the bark beetle gravity supported by another triangle group. This is called triangle gait.

The movement relationship of three pairs of legs: forelegs are the most active and flexible; mid legs are powerful but range of motion not so as the foreleg; hind legs motion range are the minimum, only to push the body forward.

Results

The bark beetle 3D virtual data model should be animated that could proceed dynamics analysis briefly for the specimens. With reference to the study methods of this section is a German architect Le Corbusier's theory 'Forms always follow function' [7] and Cuvier's theory ‘Living Conditions’ [8]. They have considered that animal’s organs form is a system that internal organs closely aligned, interaction. Any if change of one organ, the other organs will occur similar changes. The same structure is derived from the use intended of the same environment. According to the final results model of the legs Ips typographus L. has shown that Owen's ‘Structure Analogous’ [9]. From that, analysis walking function of the bark beetle also provides help for subsequent modeling.

In order to collect the relevant information better in this study we only observe each part of the separate individual specimens. Electron microscope scanning need to cover of all specimen. With gold powder, the space position of the hairs and alveolus could be observed on the specimen, but the color and material details will be completely lost. To avoid this situation it should collect information of all aspects of the specimen as comprehensive as possible before modeling. Post-production models, according to its characteristics, by contrast, meet the correctness of 3D model.

Another difficulty is the accuracy of the observed material cutting separation. At present, our laboratory equipment is impossible to compare with the compression set of the Medical Chinese Virtual Human Number One specimen [10].

From the view of application and bionics, the Ips typographus L. morphology and structure function is not yet clearly at present, brought certain difficulties for digital modeling. If the
three-dimensional model of *Ips typographus* L. is developed successful, we could do the virtual environment bionics experiment by taking the advantage of the computer, to make clear of the function relationship further.

Textures and materials need to be a good treatment when digital modeling. Those two things are related the topological structure and the movement of insect data model, the UVW coordinates of materials must be consistent with the X, Y and Z coordinate of original model that should give projection bring convenience. Object's transparency, diffuse, color and other information are simulated by computer automatically and no direct sampling accord with the laws of physics.

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