The relation between sound and music explored through animation and 3D printing

Marinthe de Bokx and Oleg Fryazinov
The National Centre for Computer Animation, Bournemouth University, UK
marinthedebokx@hotmail.co.uk, ofryazinov@bournemouth.ac.uk

Abstract

This paper describes the way to combine sound, music, animation and 3D printing in stop-motion animation. By using sound processing and 3D animation, the ensemble of objects was created where each sound is visualised and has its own style and characteristics. The final stop-motion animation was created by using 3D printing. In the paper we present the steps of the project whose output was an experimental stop motion animation along with discussing technical details of each step.

Introduction

In this project we present a way to combine sound, music, animation and 3D printing and explore the process of visualizing noise using 3D printing as a medium. From artistic point of view the project allows us to individualise every model in the animation sequence. By using sound processing and 3D animation, we have created an ensemble of the objects, where each sound is visualised and has its own style and characteristics. We implemented stop-motion animation where each model is sound-driven and carries their own personal characteristics.

This project heavily focuses on artistic impression due to some technical restrictions. We created the entire piece within two months by using an inexpensive 3D printer as this was the only one readily available on campus. These limitations had a big impact on the way the project was implemented and shaped.

This paper discusses the stages of our project, whose output was an experimental stop motion animation [1]. A screenshot from the animation is shown in Fig. 1 . Potential extension of this project can be seen in future music videos or sound related shorts.

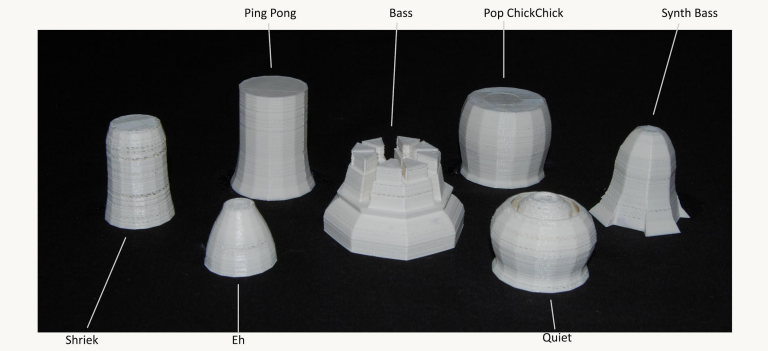


Figure 1 : *A still from the final video with added annotations labelling the names of the models.*

Relevant work: 3D printing in Animation

The animation industry uses 3D printing mainly as a supplement for stop-motion animation or for rapid prototyping purposes to create feature films [2, 3] or adverts [4]. In his melodic work Digital Pots, Jonathan

Keep [5] combined sound with 3D printing. Our project differs from Keeps in that we did not want to alter the printing process but alter the way the models would move and their aesthetics, relating to the sound that each model is connected to. MIDI compositions is also well known for their CG project Animusic [6].

Sound-driven modelling and animation

The main challenges during this project are to convey sound through movement to explore how different noises would create different shapes and motions. We chose to use an abstract music composition that we built from seven different noises. These noises were mostly created by using the first author's own voice recorded in the "Garage Band" software as it would create a warm acoustic tone and give the ensemble feeling and personal attachment. We chose these noises so that they bounce off and compliment each other, helping to make the models feel more connected with each other.

The naming of each noise (see annotations in Fig 1) helped us to keep the workflow clean and efficient, this also helped in the later stages of 3D printing when we labelled each model printed. These names mainly act as onomatopoeia, meaning that the name represents its noise. For each noise we created separate animated model. Due to the nature of frame- by- frame animation, we expected a significant number of models were going to be printed. Therefore, we chose to keep the geometry of the models to be as easy to print as possible. By starting from objects with simple geometry, such as cubes, cylinders and pyramids, we made shapes which could be fabricated quickly without the need of support structures. This meant that the models were ready to be animated as soon as they came off the printing plate. We chose a cylindrical base shape for the models, having the same base for all the models simplified our task and helped to create a consistent style across the seven different sounds. Overall, in this project the shape of the model was purely designer's decision. The seven shapes which correspond to the noises are shown in Fig. 1. For each shape we created an animation sequence of poses. Two key poses were used, one for "no amplitude" sound and a second one for the "maximum amplitude". The modelling system automatically created intermediate poses using interpolation and deformation techniques. Each model has its own rig, inner skeleton, which allowed for the deformation during animation.

Each noise was used as an instrument in a music composition, which was created as a multitrack recording. This music composition was provided to the Houdini modelling system, where each track was separately analysed and amplitude of each noise was extracted and linked to the change of the amplitude to the timeline of the animation. In the end by using sound processing we created a curve representing the change of the amplitude which we used in the animation software for the animating of the different CG models. The last step for connecting sound to animation was to align the curve of the amplitude of the noise for each model with the deformation curve that defines the animation.

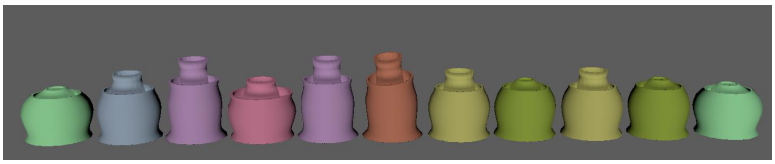


Figure 2 : *Animation sequence of poses for the Quiet noise, colour coded.*

3D printing for stop motion animation

Stop motion animation typically ranges from 12 to 30 frames per second, where more frames per second gives a smoother overall motion. Due to the time limitations faced during this project, we animated using

12 frames per second. This also added the classical stop-motion frame- by- frame aesthetic to the final animation. Limited the amount of poses we needed to print and created a bouncy hand- placed aesthetic that we liked.

To reduce the number of models for printing in this project, we used the following approach. In the animation software, the motion for each model was discretized based on the target frame rate thus giving us the set of poses for each shape. Each shape was colour-coded based on the deformation (see Fig 2). By looking at the set of resulting poses, we visually identified and omitted poses that appeared to be duplicates of each other. The resulting set was sent to be printed. For the whole animation, we printed 77 different poses for the seven models. Due to the intricacy of the sound, some sounds had more poses to be printed off.

Before printing, we made one more adjustment for the models. In the stop motion animation the models had to be aligned, so additional geometry was added to be sure that no rotational or translational adjustment would be required. Initially in the project, we were going to place the models using holes in the base, but eventually we decided to add extra geometry, which is hidden in the final animation (see Fig 4a).

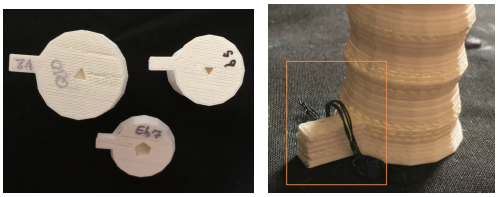
Simplicity of design and the fact that the models did not need any support structure allowed us to print the entire set of poses in a relatively short amount of time, approximately 70 hours excluding failed prints and tests. To show the texture of the model more clearly all the prints are white. The printed poses for one model can be seen in Fig 3. During the printing process, the speed of printing was crucial and therefore the quality sometimes suffered. One of the issues that appeared from the fast printing was under-extrusion (see for example leftmost model in Fig 3). We decided to leave it as it is, as we felt that it added more life into the objects and created a bigger sense of movement.

Figure 3 : *Every pose printed in the accurate sequence for the noise: Shriek. The poses look very similar, though every little change shows up clearly during the stop motion animation.*

Setting and shooting 3D printed stop motion animation

To make the shooting process fast and efficient, few steps were done. First, we labeled all the printed poses on their bases, this was not visible in the final animation (see Fig 4a). During the shooting we kept the poses sorted into their own groups in numerical order for easy access. We used a photography set up for stop motion animation, including a static camera on a tripod, remote shutter, and a static background. To prevent models from shifting during photographing, we used holes in the base of models and additional models' tabs (see Fig 4b) fitted to the black cloth by loops. Though the loops worked better, and took less time to create, very careful placement of the poses was required in order to prevent extra slots to be visible in the final animation.

To prepare for animation, we put all the frames of the final animation into a spreadsheet that contains information about each frame and which poses appear in it. To ease the post- processing in this project, we did not eliminate duplicate frames whilst shooting. For the final animation we shot 722 frames in one day. To keep the viewer's attention on the models, we used a black backdrop behind the models. This eliminated any harsh lines in the background and tonal variation. By setting the ISO as low as possible, we achieved minimal grain in our images. We set the shutter speed to the maximum sync speed in correlation with the flash, creating a clean black backdrop. We imported the resulting pictures into Premiere Pro and combined



(a) (b)

Figure 4 : *Extra geometry, black backdrop and placements for the models.*

them with the soundtrack.

Conclusions and discussion

This animation is intended to remove the gap between music-driven computer animation and stop-motion animation by using 3D printing with a strong artistic component in the final product. We believe that we achieved the goals that we set in the beginning of this project, namely connecting sound and music to that animated shapes and creating stop motion animation from physical models. The shapes in the animation got their own movements, which were driven by both music and the 3D printing process. This allowed us to achieve the effects which are hard to reproduce by using pure computer generated imagery.

In this project we have established a pipeline for similar projects which include all the steps starting from sound and music processing and transforming CG animation into the physical world of stop-motion animation by using 3D printing. This project was intended to be small scale, however workflow employed in this project can be easily reproduced for similar projects, especially if more shape analysis and similar techniques are used to automatise the process. For example, one of the areas for potential use could be music videos employing stop motion animation; another larger area can be traditional animation which employs 3D printed components. Finally, one possible extension for this project is the creation of similar stop- motion animations by employing more variations in the colour of the 3D printed poses and more advanced camera movement. We hope this project pushes for further investigation towards this direction.

Acknowledgements

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