Muscle Simulation for Facial Animation in Kong: Skull Island

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Figure 1: Shot from *Kong: Skull Island* where our muscle simulation framework for facial animation was deployed in conjunction with our blendshape-based facial animation rig. ©2017 Warner Bros. Ent. All Rights Reserved. Used With Permission.

ABSTRACT

For *Kong: Skull Island*, Industrial Light & Magic created an anatomically motivated facial simulation model for Kong that includes the facial skeleton and musculature. We applied a muscle simulation framework that allowed us to target facial shapes while maintaining desirable physical properties to ensure that the simulations stayed on-model. This allowed muscle simulations to be used as a powerful tool for adding physical detail to and improving the anatomical validity of both blendshapes and blendshape animations in order to achieve more realistic facial animation with less hand sculpting.

CCS CONCEPTS

• **Computing methodologies → Physical simulation**; *Animation*; Computer graphics;

KEYWORDS

facial animation, blendshapes, muscles

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1 INTRODUCTION

Traditionally, facial animation at Industrial Light & Magic has relied on facial rigs consisting of blendshapes and a sophisticated blending mechanism driven by facial capture and/or keyframe animation. While this approach produces compelling facial animation, sculpting anatomically valid blendshapes for fleshy and muscular faces that stand stand up to scrutiny in extreme closeups is difficult. In addition, animation techniques often struggle to achieve physically and dynamically plausible behavior when facial motion involves contact and collisions during actions like chewing and eating. Artists must correct artifacts through hand sculpting, shot by shot and frame by frame, a process which is costly and time-consuming especially when scaled to an entire feature film. In order to achieve more physically correct and realistic behavior while simultaneously reducing the amount of per-shot sculpting, we incorporated facial muscle simulation into our blendshape-based facial animation workflow for Kong in *Kong: Skull Island*.

2 SIMULATION FRAMEWORK

Muscle-based simulation techniques have been successful in adding physical details to character bodies. However, these techniques have played a very limited role in facial animation in a production environment due to their inability to achieve a sufficiently high fidelity look and feel. For humans, the simulation is often too far off-model relative to the human facial performance capture whereas for creatures, the simulation often differs significantly from the look and feel desired by the artist. To address this problem, we used the art-directed quasistatic muscle simulation framework of [Cong et al. 2016] which allows for targeting facial shapes while maintaining desirable physical properties such as volume conservation and lip

Figure 2: Face simulation model for Kong. Left: Cranium, mandible, teeth, and eyeballs. Right: Facial muscles (red) and nose cartilage (white). ©2017 Industrial Light & Magic. All Rights Reserved.

tension. This meant that the simulation could stay on-model and achieve the desired look and feel while still adding physical details thus enabling facial muscle simulation to be used as a tool in a high-end production environment.

In order to leverage this framework, we built an anatomically motivated face model for Kong that incorporated all of the interior anatomy shown in Fig. 2. The cranium, eyeballs, and upper teeth were unioned and rasterized as an implicit level set volume to form a cranium collision object. The same operations were applied to the mandible and the lower teeth in order to create a jaw collision object. We opted to represent the facial muscles as polygon meshes instead of B-spline solids as in [Cong et al. 2016] because B-spline solids were unfamiliar to most artists and relatively unsupported in our modeling tools. However, this meant that we could not obtain fiber directions by taking a derivative with respect to one of the B-spline solid parameters. Instead, we tetrahedralized each muscle and painted it with anatomically motivated origin and insertion areas that were then used to reconstruct per-tetrahedron fiber directions following the approach of [Saito et al. 2015]. The tetrahedralized flesh mesh enclosing the muscles and surrounding the cranium and jaw was obtained by morphing a tetrahedralized flesh mesh from a template model to match Kong’s high resolution face mesh [Cong et al. 2015] and resculpting the underside of it to conform to the rest of the interior anatomy.

3 BLENDSHAPE AUTHORING

We developed a workflow for using facial muscle simulation as a tool for improving the blendshapes used in our blendshape-based facial animation rig. Even the most talented sculptors struggle to sculpt expressions with consistently preserved volume. We opted to focus first on the anatomical validity of the underlying blendshapes before addressing facial motion because any improvements to the blendshapes would easily carry over to the facial animation shots. For each blendshape, we ran a facial muscle simulation that targeted a blendshape resulting in a simulated shape with the same topology. While the simulated shape closely resembled the blendshape to the point where it was considered to be on-model, it did not match exactly due to the physical constraints of the simulation. This allowed us to identify previously unidentified issues with the blendshapes such as volume gain/loss and artificial texture stretching. The blendshape and the simulated shape were then blended together by painting a spatially varying blend area to produce an improved blendshape that contained the best characteristics of both the original blendshape and the simulated shape. If the blendshape changed significantly as a result, this process was iterated using the improved blendshape as the subsequent target shape until convergence. The results of this workflow were quite compelling especially in the lips where the simulated shape exhibited significantly better lip stretching and tension. This led us to apply the same workflow to other corrective shapes used by the rig.

Facial muscle simulation also enabled us to use external forces and contact/collision to art-direct the face and give some ideas on how it should appear. This was accomplished by targeting the simulation to a particular shape and subsequently adding external forces and collision bodies in order to achieve visually interesting behavior. If desired, the resulting simulated shape could then be used as a starting point for additional sculpting. Note that it would be difficult to do this if the simulations were not on-model because the difference between the simulation and original shape would be too large relative to the change due to the external forces and collision bodies.

4 SHOT PRODUCTION

We extended our workflow to handle blendshape facial performances and leveraged it on the chewing shot shown in Fig. 1. The initial animation for this shot had many intersections of the face, teeth, and tentacles with each other. An initial round of corrective shape sculpting was applied on top of the initial animation to improve the look and feel and alleviate the most egregious intersections. For every frame of the performance, we then ran a simulation targeting the facial shape in that frame. The quasistatic nature of our simulation framework allowed us to distribute these simulations independently on our render farm to significantly reduce the turnaround time. This resulted in a simulated facial performance with improved volume preservation as well as teeth collisions which reduced the amount of time needed to sculpt shapes to correct for teeth collisions. Then, we ran a flesh simulation on the tentacles in order to squash the tentacles and resolve collisions of the tentacles with the teeth and face. Finally, we added the simulated tentacles as external collision bodies to the per-frame facial simulations and re-simulated the face to resolve any remaining tentacle collisions. The final simulated performance with tentacle collisions was blended with the corrected blendshape performance using a time-varying blend area that included most of the muzzle, lip, and brow.

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