Laughing Out Loud

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We present a novel technique to generate and control laughter using a physically based, anatomically inspired torso simulation. We use this system to synthesize motion of the trunk and to create secondary effects that propagate to other parts of the body, e.g., the arms and the head. A hybrid set of rigid and flexible components comprise the model of the torso: spine, ribs, diaphragm, and abdomen as well as neck and shoulders. We employ hierarchical, Hill-type muscles to actuate laughter movement. The result is a rich, controlled motion derived from a simple, intuitive set of control parameters which we can use to demonstrate a range of laughing animations.

Further, by utilizing biomedical research in laughter, we offer a second, innovative method for controlling the described system automatically starting from a source audio track of laughing. Our key insight, which is described in the supplemental material, is that lung pressure is a direct reflection of the strength and phase of the laughter which can be assessed from the time varying amplitude of an audio signal. From this observation, we can determine the pressure required for a desired recording of laughter. By adding a pressure-based model of the lungs to our torso simulation, we formulate an optimization problem which determines activations to produce the desired pressure profiles. We use this technique to generate animation that syncs well with a given audio track. Notably, this approach is aligned with common practices used in production animation where movement is often made to match a pre-recorded soundtrack.

Our approach differs in important ways from pure data-driven techniques, such as the impressive skin capture examples shown in [Park and Hodgins 2006] which attempt to precisely recreate a given example motion. Foremost, we argue that our approach offers a strong advantage in control over the motion. It is difficult to modify a surface model of a giggle to be more uproarious, or even to be somewhat longer, without a reasonable model of laughter. In addition, with our added emphasis placed on controlling laughter with an audio clip, we support the common practice of separating the motion generation (or capture) from the sound recording. The matching of a prerecorded animation with a prerecorded soundtrack is a dizzyingly complex proposition. In addition, our anatomically inspired, physically-based torso is superior to a procedural model, as such as one which uses a weighted blending technique. During laughter, there is rich interplay between the subsystems of the torso (i.e. abdominal cavity, ribcage, clavicles, and spine) which changes over the course of a single bout of laughter and across the range of possible laughing behaviors (a little giggle to a deep-belly uproar.)

The degree of effects depends on the intensity of the contraction and the pressure in the gut as well as contraction of the other components. Propagation is intensified if the contraction speed exceeds the damping effects of any ‘link’ in the chain. Further, our method could be made to react to external forces, so the torso would react in a physically plausible manner to disturbances. A procedural approach would not be a suitable method for this type of interaction.

The primary contributions of this paper are: 1) we introduce an anatomically motivated model for the generation of laughter motion; 2) we propose a straightforward method for controlling the activation of the model using simple, intuitive input signals; and 3) we provide an alternative approach for controlling the system automatically using an audio soundtrack of laughing.

Experimental Results.

Examples of our work are included in the accompanying video. We include manually controlled laughter: a giggle, an average laugh, and a deep belly laugh. We include a set of optimized, audio-driven laugh animations. To test the strength and range of our system, we ran the audio-driven laughter optimization over many different types of laughter, some natural, some computer generated. We observed that more natural laughs produced better results than computer generated laughs. In addition, we compare our technique to a pure data-driven animation (motion capture) and a procedural animation. Finally, we generated a set of manually controlled motions including breathing, coughing, and sneezing to demonstrate the range of possible motions that can be generated using the proposed system. For skin rendering, we show a proof of concept that was developed in Dreamworks Animation’s production pipeline on how our torso simulation can be integrated into a production setup.

References


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