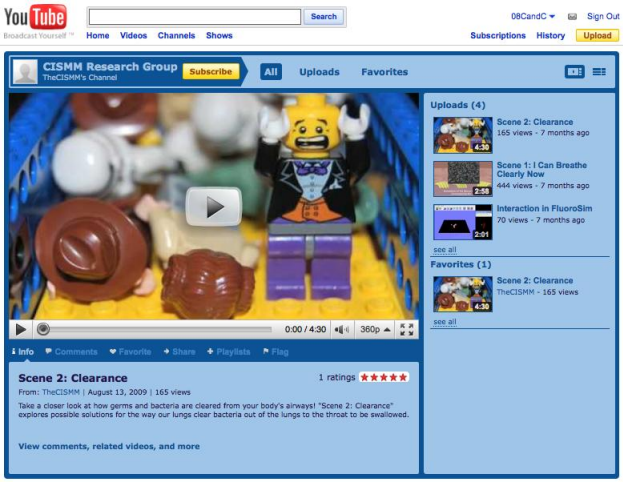
Virtual Lung Project Animated Film Series

Department of Computer Science | University of North Carolina at Chapel Hill | March 2010

The Challenge

This film series seeks to educate and inform secondary school students, teachers, and general audiences about the inner workings of the human lung. Each video describes a process the lung undergoes to function properly. Through integration of 3D models, videos clips and images recorded microscopically, fluid and molecular animations, and colloquial narration, the films combine the ideas of many researchers into our current understanding of the lung's functions and purposes. Because mucus flow and ciliary movement are groundbreaking research areas, studies are sometimes conflicting and parts remain unsolved. Creating these stories by combining data and models from multiple departments helps researchers visualize the whole picture and raise new questions about the pulmonary system. These films strive to render cilia structures accurately in scale, motion, and applied force. Mucus flow, bacteria entrapment, ciliary force, and drainage are all carefully studied and modeled to accurately convey what is known about cilia's role in clearance. Using actual data of ciliated cells, microscopy videos of mucus flow and ciliary movement within the films ties artistic rendering to real molecular data. Hopefully, our work will strengthen humanity's understanding of microbiology and chemistry and lead to therapies for respiratory diseases like Cystic Fibrosis.

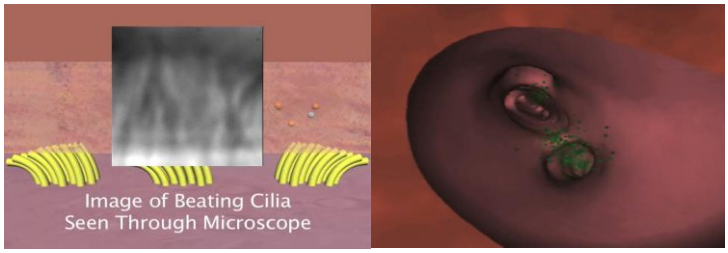


The CISMM research group's YouTube Channel, available at http://www.youtube.com/user/TheCISMM

The ultimate goal of this project is to create a complete virtual model of the lung with all its functions explained or theorized—from microscopic chemical exchanges to coughing. We will be creating interactive videos where the user can select a possible treatment for lung ailments, such as problems that plague Cystic Fibrosis patients. In a few years, we hope to have animated the entire lung so scientists, researchers, and curious users can explore the features of the lung and understand how all the components work together to make this complex organ function as it does.

Highlights

- **Film series illustrates research of multiple departments to describe pulmonary function.**
- **Utilize real data and images, mathematical modeling, and artistic depiction to create accurate and comprehensible videos.**
- **Interdisciplinary collaboration between medical professionals, artists, physicists, computer scientists, and mathematicians.**
- **Exposure to many fields of science and art, including biomedical research, computer science, biophysics, applied mathematics, video production, computer graphics, audio and lighting tech., and studio arts.**



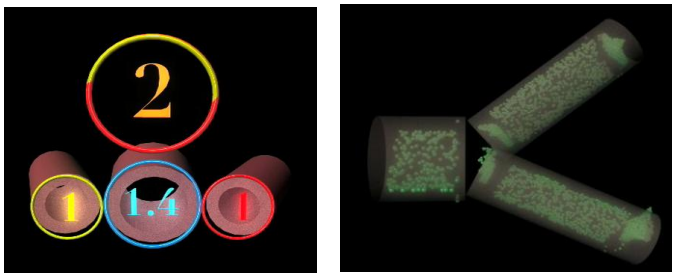
Snapshots from "I Can Breathe Clearly Now" (left) using modeled and microscope data to illustrate cilia, and "Clearance" (right) showing particle flow through a bronchiole cross section.

The Approach

The production pipeline begins with our project members storyboarding and scripting a short narration answering a question about the workings of the human lung. Once outlined, technical challenges are dynamically approached and solved using mathematical models, computer programs, and integration biomedical MRI data. We record the audio and create the soundtrack. Using programs like Autodesk Maya, Photoshop, Final Cut Pro, and Motion, the textures, lighting, animation, and modeling are configured to tell the story. In post production, the rendered frames, audio, soundtrack and final effects are composited to produce the final product, which is then uploaded to the research group's channel—The CISMM—to be shared with viewers worldwide.

Scene 1: I Can Breathe Clearly Now The first in the series, this film describes the process the lung undergoes to transport air molecules while filtering out bacteria. In this short, our antagonist, the blue dot of bacteria, journeys through the nose and into the lung through bronchioles. We follow him as he tries to find his way to the blood circulating throughout the lung. Along his voyage, he encounters the mucus that lines the lungs to protect the body against bacteria and obtrusive particles. We study the effectiveness of mucus at the microscopic level, learning that the fluid motion of the mucus is caused by pumping cilia. Using simulations and video clips of actual cilia beating, the viewer is educated about the way cilia move and create mucus flow. "I Can Breathe Clearly Now…" shows what happens when healthy lungs work properly.

Scene 2: Clearance This short illustrates how bacteria are cleared from the lung. We follow the mucus flow through the bronchioles out of the lung and propose different hypotheses of how clearance works. We still do not know how the lung manages mucus flow so effectively. In "Clearance," we animate what happens when the mucus tries to clear the lung at a constant speed, and what happens when the mucus tries to clear the lung at a constant depth. Both scenarios result in disastrous consequences. This video discusses the consequences and challenges the viewers to formulate their own theories about how the lung clears mucus.



Hypothesis studied in Clearance, illustrating the ratios of lower bronchiole to higher bronchioles (left), and mucus speed (right).

Inhaling bacteria in "I Can Breathe Clearly Now." Nose is modeled from MRI scan.

Current Project Members

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http://www.youtube.com/user/TheCISMM