Group Project 3: Operating Room Laminar Air Diffuser Flow Visualization over Manikin Using Fog Streamline Generation

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MCEN 4228: Flow Visualization
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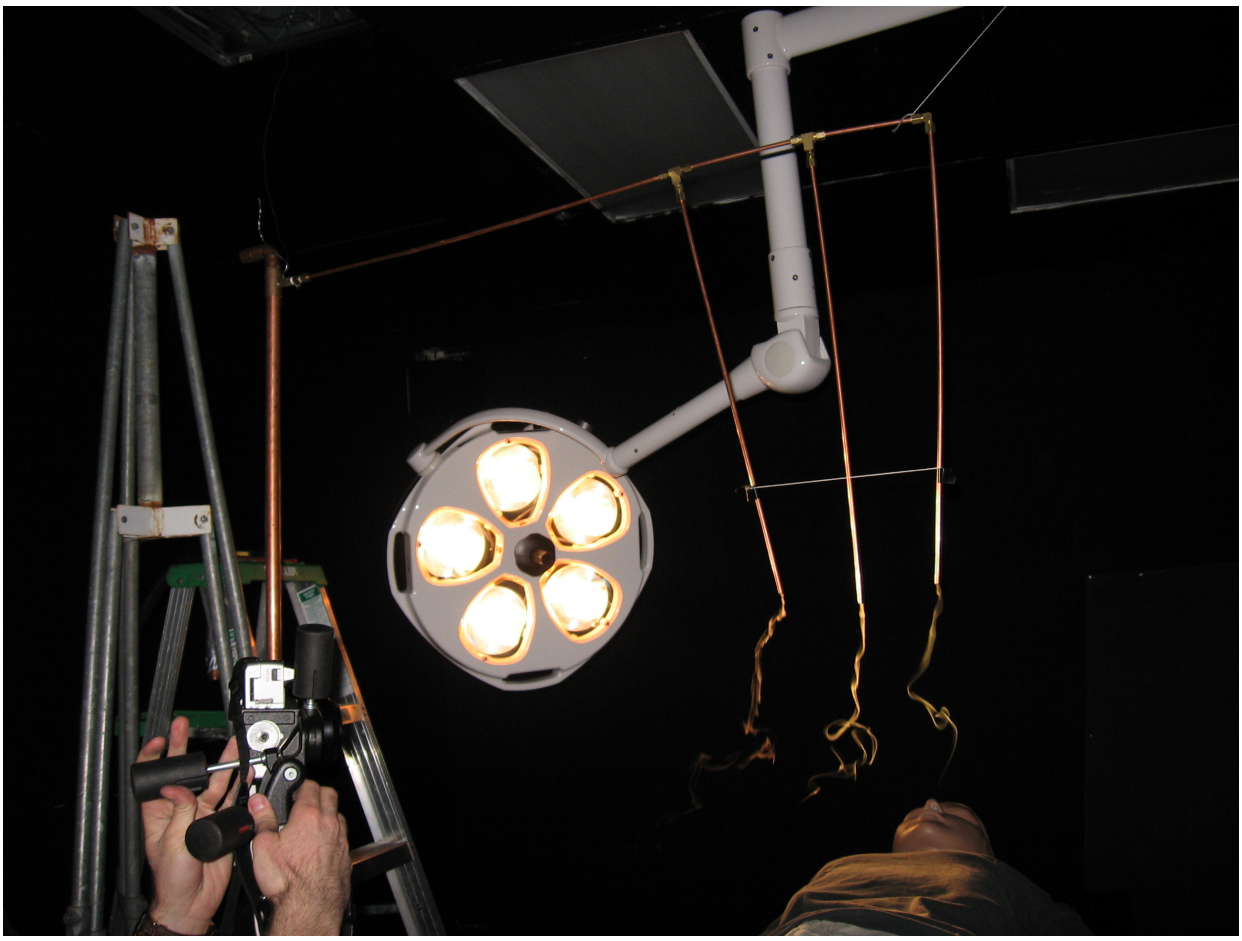

Introduction

For the third team project, we decided to investigate the air flow from the Laminar Air Diffuser (LFD) over a manikin using a fog generator to create streamlines. Fog was chosen for this project as the seeding fluid since the Ni-chrome wire, from the previous projects, appeared to create buoyant plumes, thus disrupting the flow and giving slightly less accurate results. Fog however, equilibrates to the temperature of the surrounding atmosphere as it evaporates. A manikin was used again to simulate the body of a patient lying on a surgical table.

Set Up

Two different set-ups were used in creating images of the flow. The first set-up implemented a light sheet using two high speed camera lights and sheet metal, and a bulk mass of fog exiting from the base of the diffuser (see Fig. 1). This was done by forcing fog from the generator up a copper tube and impacting it with a flat surface next to the diffuser. This allowed fog to lose momentum and slowly enter the LFD air field under a diffuser. Visualizing this was difficult because the light sheet was not intense, or thin enough to illuminate a thin sheet. However, a relatively good set of time-lapse images were created.

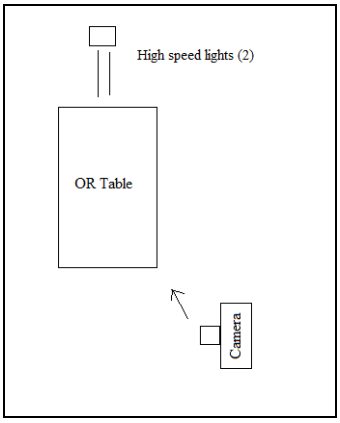

Figure 1: First Image Set-Up

The second set-up utilized a conduit system fabricated from copper tubes, along with a manifold that contained three thin tubes, to create fog streamlines. Lighting was not as important for this visualization since a sheet was unnecessary to illuminate single streamlines (see Fig. 2).

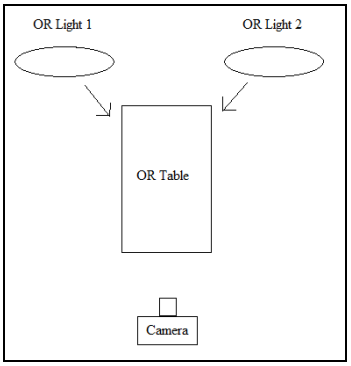

Figure 2: Second Image Set-up

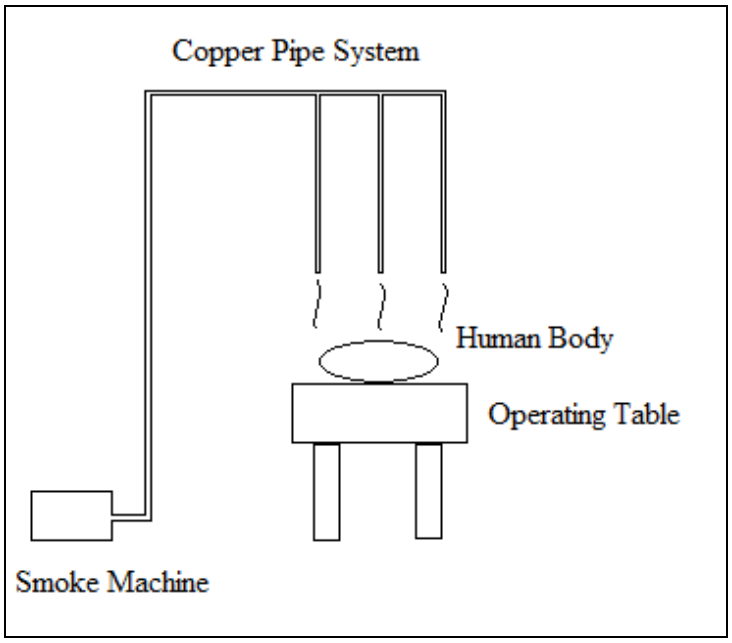

Figure 3: Second Visualization Set-Up

The conduit system was fabricated from copper in order to cool the fog, thus keeping it from evaporating too soon. The copper tubes that created the streamlines were approximately 1/8 inch in outer diameter, and 23 inches long each. All of the tubes where connected using brass fittings. The tubes were place approximately24 inches from the torso region of the manikin, which laid 6 feet from the ceiling.

The LFD operating conditions were: flow velocity = 50 fpm and flow temperature = 50 degrees F. The ambient air temperature was around 60 degrees F for all of the images.

Tom Rachlin

After cropping some of the copper pipe and mannequin out of the picture, I played around with changing the saturation feature in the *black and white* option under the image toolbar. This allowed me to keep the darker shades in the back, while bringing out the lighter colors of the smoke.

With the diffuser on, my picture definitely shows an air current to the left of the picture. At the moment the picture was taken, there was no reason to predict this would have happened. However, given that the hot pipes as well as the heat of the smoke machine may have caused some natural convection flowing upward on the left outside the frame of the picture. This would cause the smoke to be pulled to the left as there is an upward current on that side. Otherwise, my intent was realized, and the conditions were controlled, so overall it was a successful picture.

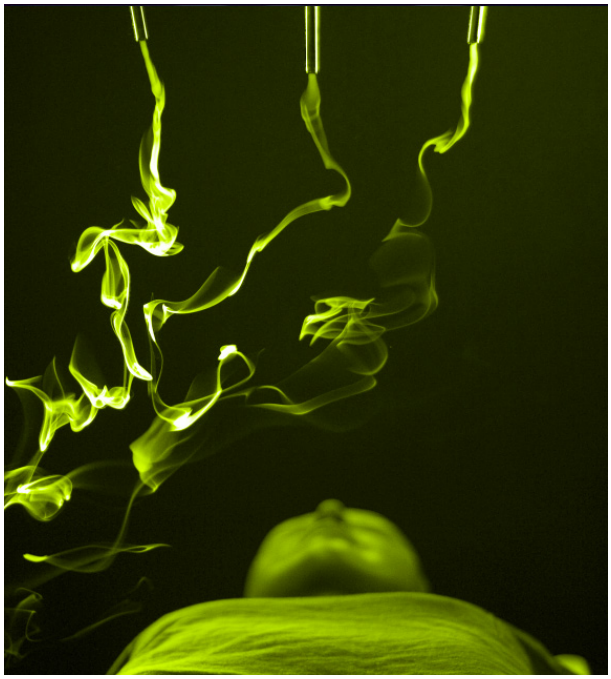

Figure 5: Tom's Image

Specifications for Tom Rachlin's image:
Camera: Canon EOS Digital Rebel XT
Shutter Speed: 0.4 seconds
f/stop: f/22.0
Max Aperture: f/1.8
ISO Speed Ratings: 1800
Focal length: 50.0 mm
Flash did not fire

James Kostrzewa

For the first time in three attempts this sequence of photographs reveals laminar flow over a manikin. The air flow was traced using stage fog instead of vegetable oil used in the smoke wire technique. This worked much better because the temperature of the fog is very close to the ambient room temperature. The vegetable oil reaches temperatures of 200 Degrees Fahrenheit. This caused a very high buoyancy affect tainting the actual visualization of the air. It was found that the fog best simulates the air flow out of the Laminar Flow Diffusers (LFD) when it is leaked out instead of pushed at a high velocity. This set of photographs represents the laminar flow found in the operating room from laminar flow diffusers.

Using PhotoShop CS4 I inverted the photographs. This technique switches colors with the opposing color found on the color wheel. I particularly liked this effect because it really brought out the definition in the smoke, which is what I wanted to accomplish. I used the clone stamp tool to remove the copper wire that transported the stage fog to the diffuser.

Figure 6: Jimmy's Image

Specifications for James Kostrzewa's image:
Camera: Canon EOS Digital Rebel XT
Shutter Speed: 0.4 seconds
f/stop: f/22.0
Max Aperture: f/1.8
ISO Speed Ratings: 1600
Focal length: 50.0 mm
Flash did not fire

Jeff Payne

For my part of the group project, I decided to image a single fog streamline from the manifold, as a portrait image. I also inverted the image, allowing for more flow details to become visible. The visualization of a single streamline allowed for more focus on the direction of part of the downward air flow. Too many streamlines, especially in turbulent flow, may have been too distracting, leaving out important details that could be lost in the image. The streamline captured in the image appeared to move the left of the field of view in an attempt to move around the manikin on the surgical table. It is obvious in the image that the flow is not laminar, but turbulent, like the previous project reveled.

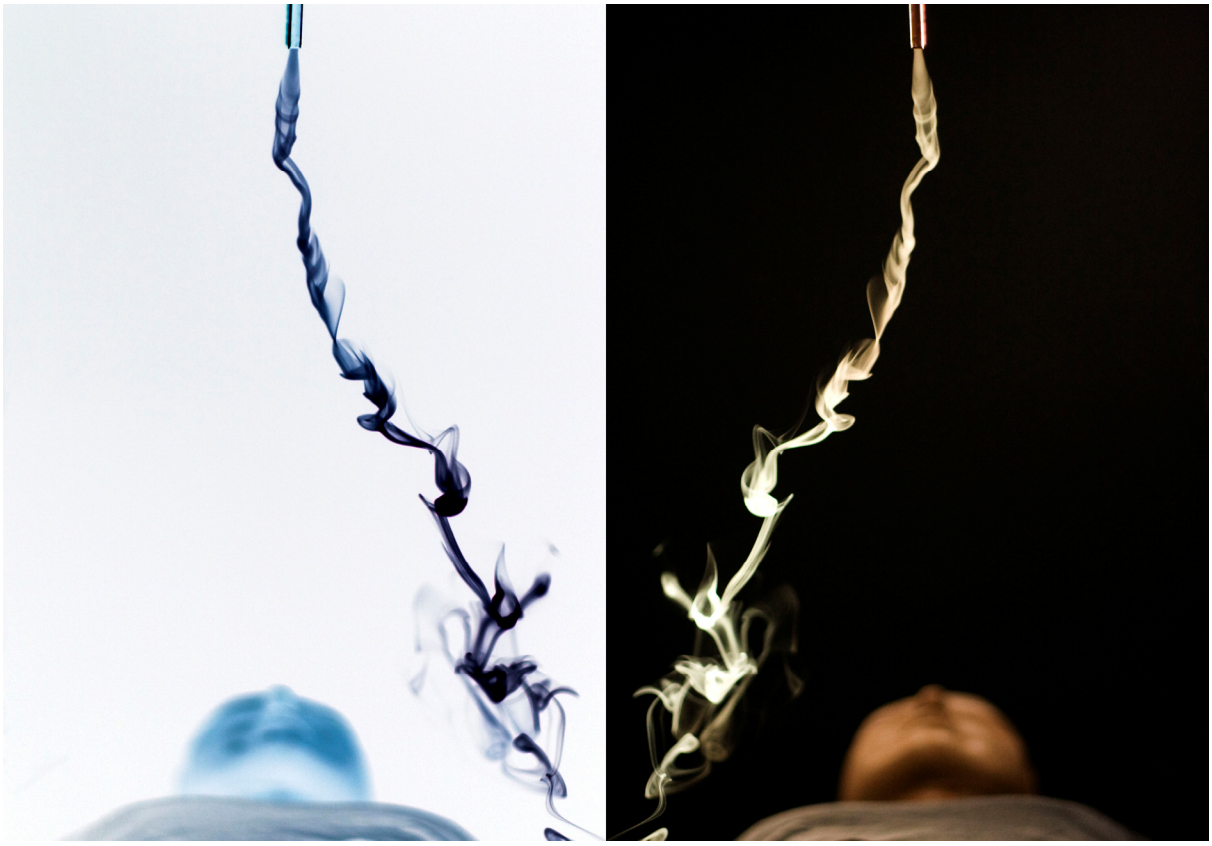

Figure 4: Jeff's Image

Table 1: Photographic Technique

Field of View (FOV)	12 in x 24 in (width x height)
Object Distance	~5 ft
Focal Length	50.0 mm
Aperture	f/1.8
Shutter Speed	1/800 sec
ISO setting	1600
Exposure	Manual
Original Image Size	2304 x 3456 (X x Y)
Final Image Size	4608 x 3196 (X x Y)

Photoshop Adjustments

The curve adjustment in Photoshop was modified slightly to increase the contrast and color intensity, and the brightness was reduced slightly to -4.1. Also streamline from the right copper tube in the manifold in the FOV was clone stamped out, and the image was slightly cropped to omit a heat pad which wasn't used in the image set-up. To add an artistic effect, as well as added fog visualization, the image was mirrored and inverted from the original image.

Image Evaluation

I think that this image does an excellent job of revealing the fluid physics that occur over a simulated patient in an O.R. This technique allowed for a more accurate representation of the fluid flow, considering the smoke-wire technique contained buoyant plumes that interrupted the flow. However, I believe there are ways to improve the imaging techniques. Lighting was not as much of an issue for this project since a fluid sheet was not being visualized. However, other lighting techniques may have produced better results, such as using a YAG laser to illuminate a light sheet [1]. Another set-up could include using a thermal manikin to determine if the heat plume affects the LFD flow.

References

1. http://en.wikipedia.org/wiki/Nd-YAG_laser