Teams First Report

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Flow Visualization MCEN 4151-001

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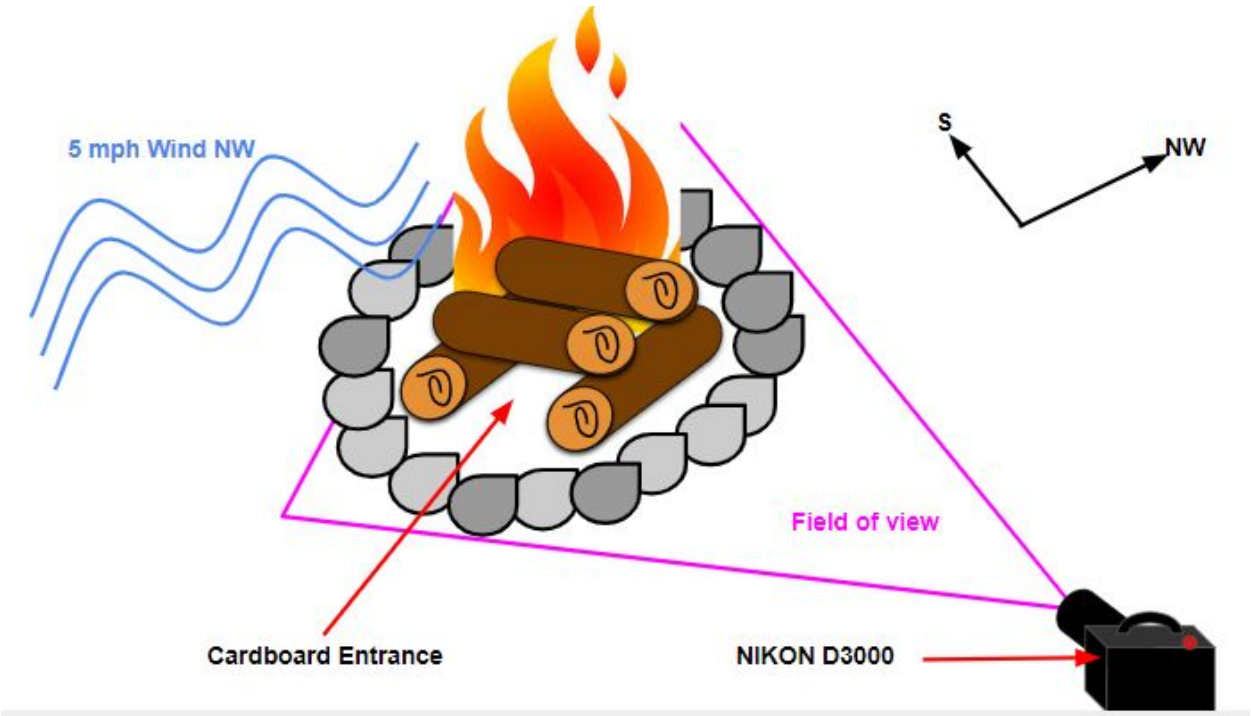
Fire Perspective

Our goal for the first team image/video was to focus on capturing the flow of fire in various conditions. Each of the team members experimented with several apparatus set ups to create a flow of fire. These setups varied from using flammable objects in static to dynamic motion. The photo below is of a campfire apparatus which gives description of the wind, added cardboard, log setup, and the direction of the camera's field of view.



The fire was created with four logs, two on the bottom and two orthogonal logs on top. This allows for a safer region to add different material in the fire by entering between the two logs on the bottom, which were spaced about one foot apart. This flame is roughly two and a half feet tall by three feet wide. The observed flow is caused by the wind blowing north west on the campfire. Also noted is the ashes that are erupting from the fire and scattering into the background. This is happening because the force from the pressure gradient, due to heat on the particles, is greater than the impending force of gravity. This can be seen in Bernoulli's equation (Weisstein):

$$P + \tfrac{1}{2}\rho V^2 + \rho g H = C \qquad \textbf{Equation 1}$$

In general, the force from gravity is also small because the mass of the particles rising are relatively small. Another notable point is that the intensity of the flame differs in specific

regions. The image was inverted to create a higher level of focus on the flames intensity and flow for the observer. The darker regions of the fire, which appear to be a darker blue in the inverted image, represent regions of higher temperature. The darker colored regions are actually the whiter looking regions seen in the original image. The spectrum of visible light from a fire, with the exception of blue, ranges from 525 degrees celsius to 1500 degrees celsius respectively from red, to orange, to white (Maggio 2011). This means the brighter regions, which appear more white, are the hottest regions of the fire. Since this is an open sourced fire it is hard to get a specific reynolds number. This report will assume the flow is turbulent because of the vast pressure gradients associated between the changing spectrum of light within the fire. Therefore our Reynolds number is greater than 4000.

The visualization technique used is simple. As described above, only four logs were used to keep the fire burning. Outside, the relative temperature was 48 degrees celsius. Lighting for the capture was not used. The flash was turned off, as were the lights near the campsite. This is because the photo was captured at night, and the light from the fire was enough to keep background objects out of the image while still giving detail of the flow itself. To create the rising ashes, just add four inch squared cardboard between the bottom two logs and wait for the cardboard to break apart. Once it is broken into tiny pieces, the pressure gradient from the heat will lift them like tiny fireballs.

Originally, the image captured a five by four foot field of view. After cropping, the image was reduced to about a four by three foot to center and focus on the flame itself. The distance from the object to the lens was roughly four ft. A 15-55mm lens was used with a focal length of 55mm. This photo was captured with a nikon d3000 DSLR, which is a digital camera. The original image is 2896 x 1944 pixels, and the final image is 1209 x 696 pixels. To capture this image at night, adjustments to aperture, shutter speed, and ISO settings were required. The choice to have a high shutter speed was because of the fast motion of the fire in response to the wind. Aperture had to be adjusted around this variable to allow enough light to capture the image- since it was shot in the dark. The final settings were ISO-1600, shutter speed 1/400 secs, and aperture 5. Final edited image has an inversion effect and a 1.25 saturation ratio.

Before Image

The image captured was intended to express the flow of a natural campfire under wind conditions. Initially, the intent was to gain experience in capturing motion in a dark setting with the nikon d3000. The best part of the image was the editing done, which shows the fire inverted. This gives observers a better perspective of flow in the fire. The physics of the fire were captured fairly well considering the external wind and rising ashes. Next time, there should be enhanced controls of the apparatus by using a leaf blower to change the wind flow. All around, the content of the photo presented a new perspective of fire flow and the associated physics.

References

Maggio, M. (2011, August). Fire 2: Color and Temperature. *http://maggiemaggio.com/color/2011/08/fire-ii-color-and-temperature/,* Retrieved October 5th, 2018

Weisstein, Eric W. "Bernoulli Differential Equation." From MathWorld--A Wolfram Web Resource. http://mathworld.wolfram.com/BernoulliDifferentialEquation.html Retrieved October 5th,2018