Team Third

Flow Visualization: The Art of Fluid Flow

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Background: The hope in creating this picture was to work as a finale to all the images taken in Flow Visualization. I wanted to incorporate elements that I had learned in all the other images and apply those methods to my favorite image. Inspired by other nighttime images with long exposure times, I wanted to capture the movement of Boulder Creek. The image goal was to visualize a time development of the flow pattern. By using lit candles frozen in ice, there was a powerful light source that literally illuminates the river's flow patterned to be revealed. By capturing this image, I hoped to shine some light on the movement of rivers in a time development rather than a single exposure. This project, Team Third was done individually but inspiration was provoked with teammate Michael Bruha to use combustion as a light source at night time with a long exposure. In the many images captured in my attempt, I fell this image best captures the creek's movement and illuminates the flow.

Image Capture: This image was captured at night (10pm) before the moon had risen at a point with no artificial lighting. The creek provided a great real-world application of fluid dynamics. The subject illuminating the river was a block of ice with six ¼" candles frozen vertically into it. The candles were held vertical in a bowl with peanut butter stuck to the bottom of them. The cereal bowl was then filled with 2" of water and frozen in a domestic freezer. Material included here was a lighter, candles, and the bowl to make the ice boat. The experimented was conducted by first setting the camera location and settings (see photographic technique below for details) and framing the camera to capture the creek. Then 35' upstream of the camera the candles frozen in their ice boat were lit. Returning to the camera, a 10 second delay was set with a 30 second exposure. Once the delay began, I quickly moved to set the candles into the water. It helped that one; there was a rock protruding enough from the bank to place the candles into the main flow, and two; there was limited wind allowing the candles to go un-extinguished. With the 10 second delay, there was adequate time for the 30 second exposure to capture the entire path of the candle as it moved downstream. After the image was captured, the candles were collected from the creek for proper disposure. It is suggested only ice and wax candles be used if this image is to be recreated to minimize environmental impact should post capture extraction not be possible.

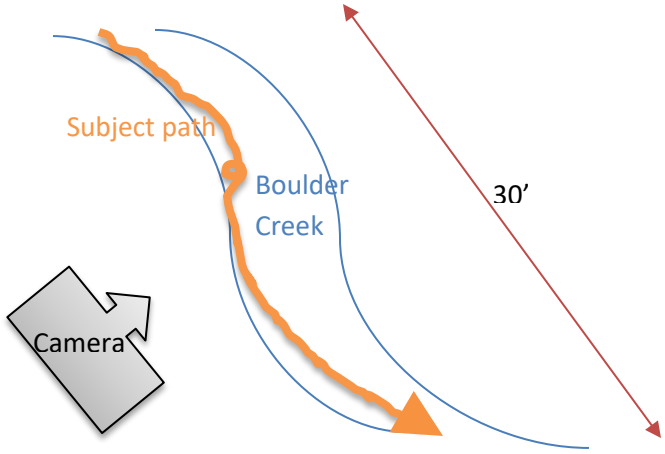

Figure 1: Image orientation

The image captures the movement of the candles as they move down Boulder Creek. The flow path is evident and clearly illuminates the path the candles were pushed toward. Notable is the small loop after rock where the subject was placed into the water. Here, the instability caused by the rock shows the creeks water in an Eddy. Also interesting is the brightness of the subject along its path. As the brightness is relative to the exposure time, the brightness is then proportional to the speed of the subject. This highlights the slowness (where it's quite bright) in the Eddy relative to the end where it enters the stream center and is significantly less bright. Given the exposure time and distance traveled an average velocity is given, 15 m in 30 seconds equates to .5 m/s but certainly much of that exposure is at the slower upstream part of the image and minimal downstream in the main creek flow path. Assuming the brightness is linearly relative to speed, it can be estimated that the speed reaches up to 4 m/s. Such a crude estimate seems realistic given the witnessed speed of the subject.

Photographic Technique: This image was captured using a Canon EOS Digital Rebel. Using the long exposure was suitable given the darkness of the environment. As such, setting the focus was manually preset in a lit area using similar subject distance. The camera was fixed and delayed to minimize motion blur given the long exposure time of 30 seconds. The aperture was set to an f/6.3, a compromise between allowing enough light and establishing adequate depth of field as the subject moved downstream toward the camera. ISO-400 was used to minimize image graining. The focal length was 18 mm, with a center weighted average setting. The result was a 4272 x 2848 pixel image. The original image was edited using GIMP to increase contrast for better context emphasizing the lights which brought out the near creek bank.

Image 2: Original Image

Takeaways: This was the most difficult image that I captured. The first 3 trials consisted of most candles being extinguished. This was fixed by using a larger body of ice rather than individual ice cubes. Likewise, the image was retaken multiple times to get the timing right and fully capture the exposure using the entire image frame. If it were done again, a partner would have been ideal rather than hurrying to get the candles in the water in time of the camera delay. I'm very happy with the results and pleased to have an image I obsessed over.

References:

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