Cat Drinking Water

Patrick Zimmer
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The intended purpose of this image was to examine how some organisms deal with water. This image looks at the relationship that a cat has with water. This image demonstrates how a cat drinks water from a free stream of water coming out of a water faucet. I have notice over that last couple of years that my cat enjoys drinking water out of the water faucet and I wanted to capture how he gets the water into his mouth from a free stream. In addition I was trying to capture something was has not been displayed as much on the course webpage as everything seemed to be very scientific, I wanted to capture something a little different.

In order to capture this image I had to adjust the water faucet's flow rate so the cat would be able to drink the water and so I could capture the water flowing with minimum motion blur. The general 'apparatus' is shown below in Diagram 1. As we can see the cat is about a centimeter away from the outlet of faucet at which he begins to start drinking the water. The rest of the water was allowed to fall freely in a free stream. The camera was placed slightly blow the cat to get the proper angle and there was some general house lighting that was to the upper left of the subject.

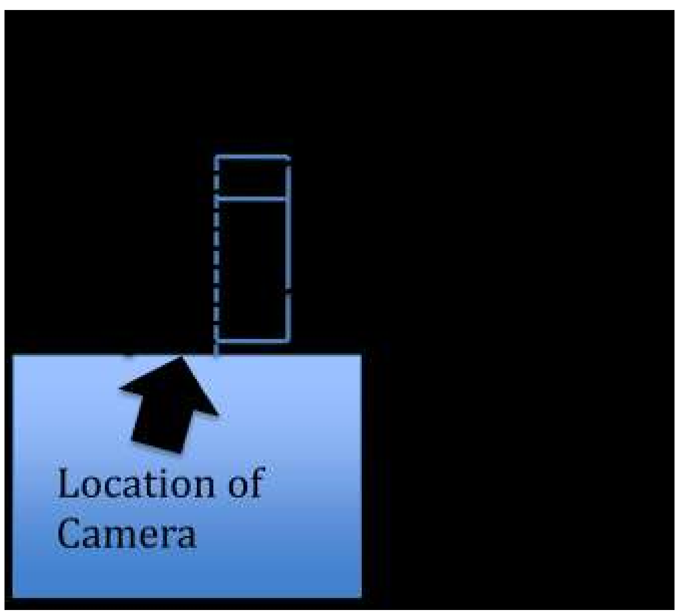

Diagram: 1

As we can see from the image there are several different fluid properties that are being displayed one of the most notable being surface tension. Surface tension is caused by the increased attraction between molecules that occur at the exposed surface [3]. Within the central portions of the liquid the molecules are attracted to one another evenly with intermolecular forces, so each molecule feels the same effect from each of its neighbors. However on an exposed surface of the liquid the molecule does not have equal forces acting on them. As shown in the diagram below the molecule on the surface is pulled inward and to the sides causing a tension like force to develop. The exposed molecules experience stronger attractive forces to each of their neighboring molecules generating the surface tension. In Diagram 2 we can clearly see how these forces are developed at the surfaces of liquids.

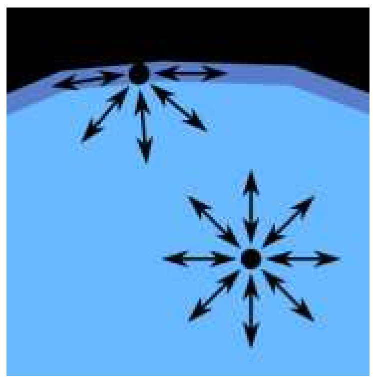

Diagram 2: Surface Tension [3]

In the image that I have selected we can see several different effects that are caused by surface tension. If we look at Image 1, we can see that there are two interesting effects that are called out. Effect 1 shows how surface tension caused the water to 'wrinkle' over itself when it's flow is interrupted. The surface forces on the water keep it together with out splitting into smaller water droplets. The second effect is causes as the water converges after it flows over the cat's tongue and forms another free stream. However we can see the free stream after the cats tongue as a reduced area and very smooth surface effects.

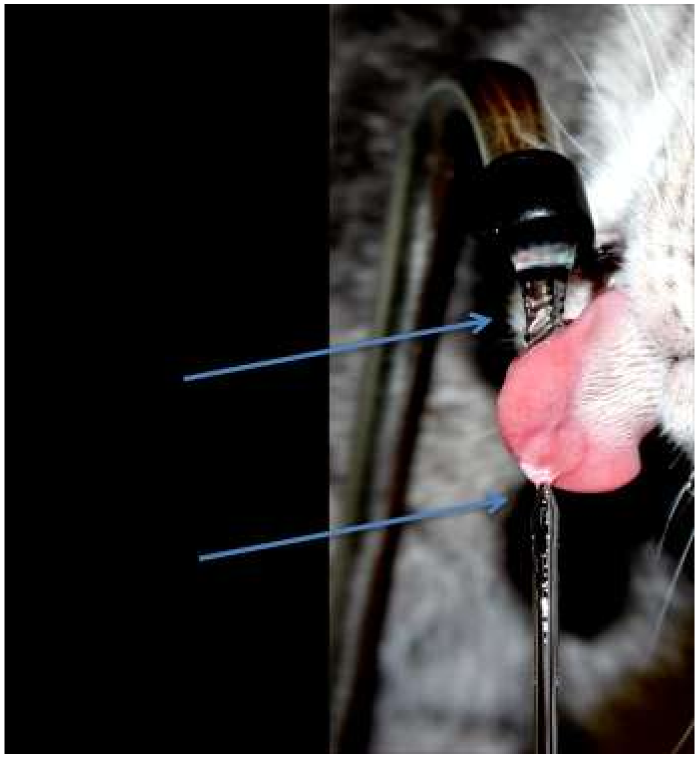

Image 1

After looking at these interesting effect caused by surface tension we can further examine the fluids behavior by looking at the Reynolds number by estimating the flow rate of the fluid. According the measurements that I have made we have found that with a flow rate of 40 oz/min ($1.97x10^{-5}$ m^3/s) with a stream diameter of approximately 1 inch. Having the volumetric flow rate we can then determine the velocity of the fluid given that (Volumetric flow rate is equal to the cross sectional area times velocity.)

Volumetric flow rate = (Area)*(Velocity)

Velocity = (Volumetric flow rate)/(Area)

Velocity = (0.0000197 m^3/s)/((0.0025 m)^2 π)

Velocity = 1.00 m/s <u>~ 1 m/s</u>

Given that we have found the velocity of the water we can then determine the Reynolds number given the relation ship of $\mathrm{Re} = \frac{\rho V L}{\mu} = \frac{V L}{\nu}$ [2]. Using the length of the stream to be 0.254 m, the velocity to be ~1 m/s, and the viscosity to be $1.004x10^{-6}$ m^2/s we can determine that the Reynolds number is 252988. This Reynolds number suggests that we have a turbulent flow [1], which makes sense as we are examining water flowing freely out of a faucet.

The general technique used to capture this image was done by using standard lights and the build in flash from the camera. Although this was not the most idealistic set up it work provided I did not have any external lighting sources that were available. The camera was set in using the macro mode to get the more detail. With that said the camera settings were as fallows: F-number 5, exposure time 1/60 and a focal length of 43. We can see that these settings provided a great depth of field and still allows for the detail to be shown in the fluid flow. In addition there were some small altercations and adjustments that were made to the image as well. The adjustments made were done to enhance the viewer's focus to the fluid flow interaction of the cat and the water. The levels in the image were adjusted and the image was cropped to bring the viewer closer into the action.

Based on the dimension of the original photo, fluid velocity, exposure time and the field of view we can determine the image blur that occurred during the capturing of the image. As we can see from Diagram 3 the dimensions of the image are 4272x2848 pixels or ~24x10inches. Given that the fluid is moving at approximately 1 m/s we can then determine the distance it has traveled by knowing the exposure time. As Distance = (time)*(velocity) we find the fallowing: [4]

$$D=(1/60)sec*(1m/s)$$

$$D= 0.016\ m = 1.6\ cm$$

Knowing the distance traveled we can then determine the number of pixels that it has traveled and then the motion blur. This is done with the following relationship:

$$(2848pix/0.254m) * 0.016\ m= 179.4 \sim \mathbf{180\ pixels}$$

This 180 pixel motion blur is concentrated in where the fluid is flowing and it not as noticeable over the larger scale of the image as it only represents 6% of the image.

Diagram: 3

In general I feel that this image revels and interesting relationship that an organism has with water. As we can see from the image the cat's tongue actually draws the water back into its mouth on the backside of the tongue not on the front like on would expect. In addition is also show the preference of how cats like to drink their water. It is still a mystery as to why he likes to drink from a free stream of water but never the less he allowed me to take several hundred photos while he quenched his thirst.

Citations:

1. Çengel, Yunus A., and John M. Cimbala. *Fluid Mechanics Fundamentals and Applications*. Singapore [u.a.]: McGraw-Hill, 2006. Print.
2. "Reynolds Number." *The Worlds of David Darling*. Web. 2 Apr. 2010. <http://www.daviddarling.info/encyclopedia/R/Reynolds_number.html>.
3. "Surface Tension." *Wikipedia, the Free Encyclopedia*. Web. 02 Apr. 2010. <http://en.wikipedia.org/wiki/Surface_tension>.
4. "Flow Visualization Course : Course." *University of Colorado at Boulder*. Web. 02 Apr. 2010. <http://www.colorado.edu/MCEN/flowvis/galleries/index.html>.