Using an Infrared Webcam to Measure Heat Loss

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Introduction/Purpose

Thermal imaging is a great way to determine where heat escapes from your home most easily. Every object which has a non-zero temperature emits some sort of light in the form of blackbody radiation, so thermal imaging cameras detect light in the infrared spectrum to determine the temperature of an object. However, thermal imaging cameras are very expensive (around $5000, according to Google Checkout), and often require training to use. My goal for this experiment was to see if it was possible to build a much cheaper infrared camera using a web camera which could also be used to measure heat loss.

Hypothesis

A webcamera can be used to determine where heat escapes in people's houses.

Experiment

To test my hypothesis, I planned to simply build an infrared camera and tried to see if the camera was able to detect changes in temperature.

Design/Construction

I used a labtec digital webcam for my camera, and followed online instructions (http://www.wikihow.com/Make-a-Webcam-Into-an-Infrared-Camera) to take apart the camera, remove the infrared filter on the camera, and put a visible light filter in its place.

Calibration

Figure 1

In order to confirm that my camera was working, I simply pointed at a $5 bill to ensure that the white stripes that is provided as a security measure were indeed visible with my camera. Figure 1 shows this photo.

Data

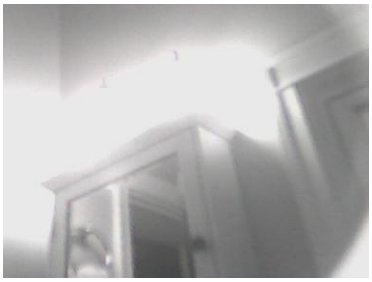
The following photos are pictures I took with the infrared web camera. Descriptions of the pictures are located below the photo.

Tree illuminated by light next to house at night.

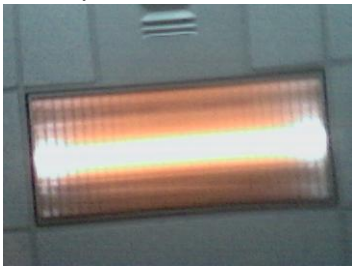
Windows with beige shutters on them.

Picture of a home taken during the day.

Picture of a window taken during the day. The bottom half of the window is open.



Incandescent lightbulbs.

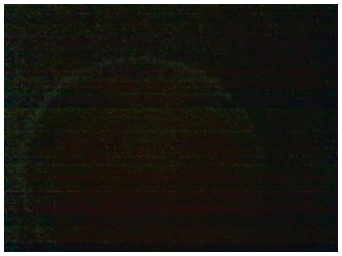


Flourescent lightbulb with grating on it.

Flourescent lightbulb without grating.

Picture of a cup of hot water taken in a room with one flourescent light.

Picture of a cup of warm water taken in a room with one flourescent light.



Picture of a cup of ice taken in a room with one flourescent light.

Picture of cup of hot water taken in a room with no light.

Picture of cup of hot water taken in a room with no light.

Picture of cup of ice taken in room with no light.

Analysis

Light Photos

From the photos it is clear that although incandescent light bulbs turn up as white light on our infrared camera, fluorescent lights give off a colored tint—green or red based on the grating around them. A fluorescent light bulb without grating gives off a green tint. This may prove useful in determining what kind of light bulbs people have, however we need to look into whether the camera needs to be pointed directly at the light in order to see the color.

Cup Photos

It is clear from the photos of cups at different temperatures that the web camera does not detect IR waves emitted due to blackbody radiation. All of the photos of the cups turned out black, meaning it is not possible to detect differences in temperature using an infrared web camera.

Home Photos

The photo of a partially opened window illustrates that the webcam fails to detect heat loss from a house. An open window should show different temperatures on the open portion of the window as opposed to the closed portion (whether the temperature is higher/lower depends on weather). However, the IR webcam made no distinction between the open and closed portion of the window. Although windows do appear dark in photos of homes, this is not because they are cooler than the outside temperature. Rather, they are dark because there was no light inside when the photos were taken. Similarly, the windows which appeared white were white because of the shutters on them, not because of heat escaping from them.

Conclusion

Based on our data, it is not possible to detect heat loss from a home using an infrared web camera. Although the camera does detect reflected infrared light, it fails to detect emitted infrared light for objects at temperatures close to what people live in. However, the camera can be used to differentiate between fluorescent and incacdescent lightbulbs, which may be useful in the future.

Reasons for Failure

The primary reason for failure of the camera is that the light detector on the web camera only captures images in the near-infrared spectrum (about 800 nm to 2500 nm according to Wikipedia), and that most objects we encounter are not hot enough to emit light in these wavelengths yet. In fact, (again according to Wikipedia) an object would need to be about 800 degrees Celsius to emit light in the near-infrared spectrum!

Future Work

One thing that might be worth trying is to buy a thermal imaging camera and take photos of an entire neighborhood, and plot the results on a Google Map so that people can see how hot their neighborhoods are.

Another thing we might want to do with the camera is use it to detect fluorescent vs. incandescent lights (however I'm not sure how useful this is given that this is easy to detect with the naked eye).