Proof of Concept Respirator Lens Fog Test Chamber

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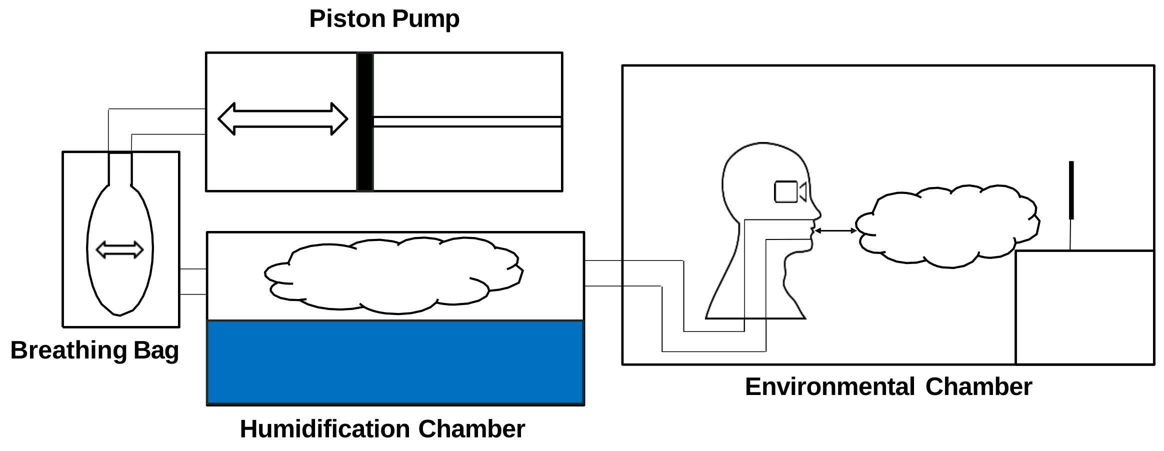
Background

Respirator fog primarily occurs when the user is under a high physical workload, and when operating in cold weather conditions. The difference in temperature and humidity of the air inside the respirator and the external face of the respirator lens leads to ideal conditions for the formation of condensation.

Currently, the standard tests used to evaluate the resilience of a respirator lens to the buildup of fog require human subjects. They rely on test participants to don a chilled respirator in a cold environment, perform an eye exam by reading a standard Snellen eye chart, perform light exercise, and then repeat the eye exam. All measurements in these human-use trials are subjective, qualitative, and reliant on the human test subject's opinions and observations.

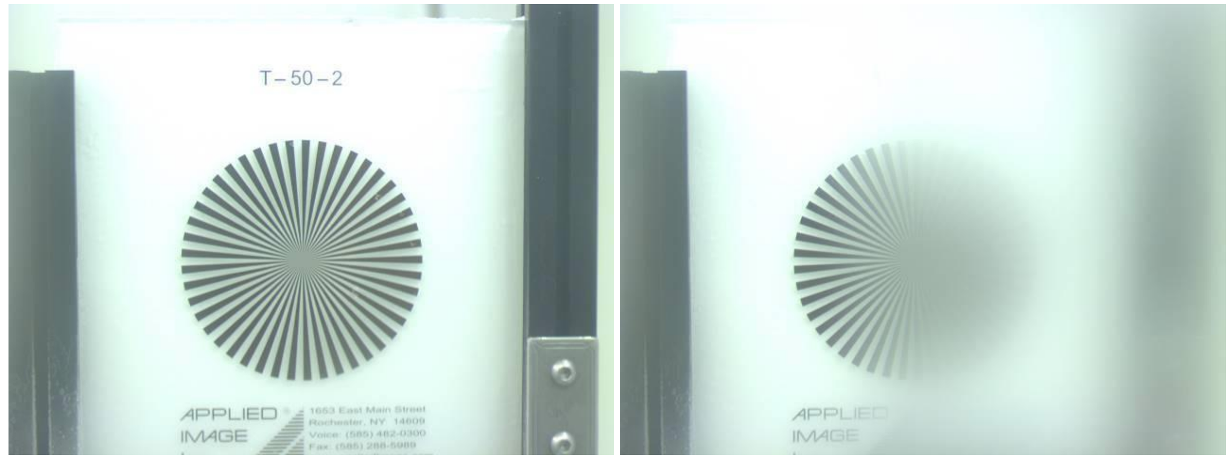
The ultimate goal of the development of an unmanned respirator lens fog test chamber is to provide a repeatable, objective measure of lens fogging that could be an alternative to the subjective, manned test method that is currently utilized. This would create a method which could potentially be used to obtain consistent results for a respirator across individual laboratories without the need for introduction of the human variable.



Approach

The primary element of the current, manned tests, that needed to be recreated in an unmanned system was the human component. This was accomplished by utilizing a heated metal headform fitted with a camera in the right eye, and a hole in the mouth connected to a heated, humidified ventilation system. In all, this modified headform mimicked the ambient skin temperature, eyesight, and breathing of a human subject, all while providing a sealing surface for a respirator.

The headform was then mounted within a small, chest freezer, which was fitted with internal lighting and provided top-down access to the headform via an access hatch. A star chart target was also mounted at a distance in front of the headform. Tests could then be conducted by donning a mask onto the headform, starting the ventilation system, and capturing photos at a set acquisition rate.



Photos taken at the start (left) and after 15 minutes (right) of a fogging trial conducted using a prototype respirator with no anti-fog coatings applied. Fog began creeping inward from the outside perimeter of the mask throughout the test, resulting in a half-fogged lens. The effects of the fog make the individual tines of the star chart indistinguishable on the right side of the right image.

Data Analysis

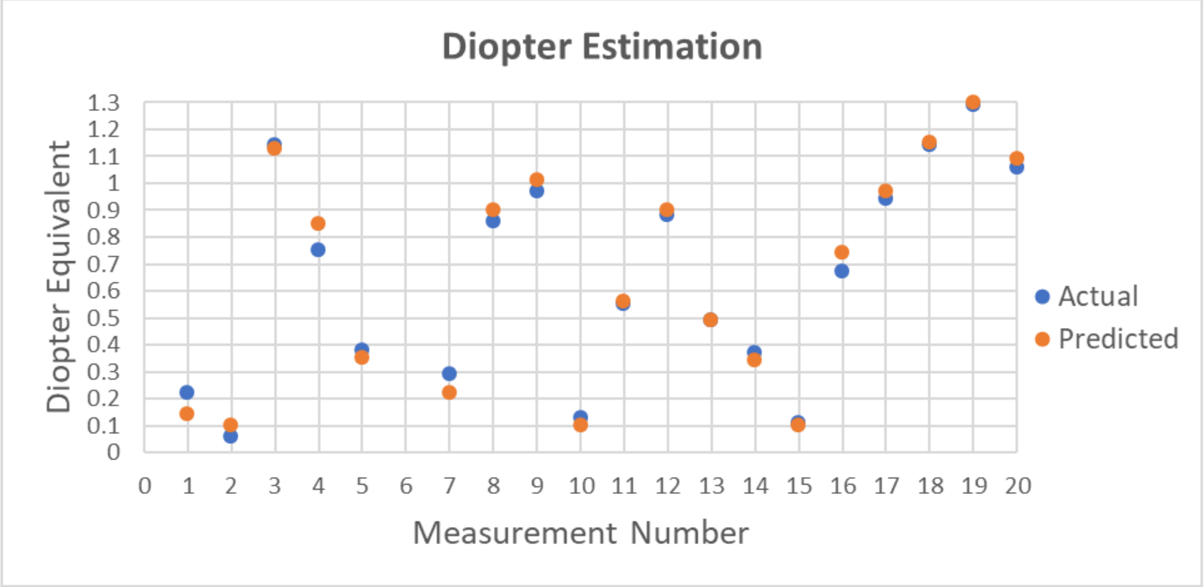
For the purpose of this fog tester, the visual impacts of fog were broken into two components: the obscuration factor and the blurring factor. The former is essentially a measure of contrast change of the image, and is similar to the visual effects caused by atmospheric fog in the air. These obscuration effects are caused by a large number of small water droplets on the lens, scattering light perpendicular to the viewing surface. Whereas the blurring factor is more similar to the effect caused by a pair of glasses. All instances of lens fogging are at least partially impacted by both of these metrics

Custom software was written within the Wolfram Mathematica scripting environment in order to analyze the photos taken during a trial. Contrast change was determined by taking an average of the pixel values across each image, and tracking the change in these values as the trial proceeded. These contrast ratios are then converted to equivalent haze percentage scores by comparing the trial values to the data collected using a set of photos captured at known haze percentages.

The blur response was calculated by performing a Laplacian operator using a standard convolution kernel, and taking the variance of the pixel values in the resultant image. By taking a series of photos through known diopter lenses, a calibration curve was created to relate these blur response values to a corresponding diopter equivalent score. In practice, this allows for a direct comparison of the blurring effects from water droplets to the blur caused by wearing a set of prescription eyeglasses.

Initial Results

Initial data has indicated repeatability and consistency of the metrics collected, including that of the correlation back to diopter equivalents. A brief check of the system using a random selection of known diopter lenses showed a tight correlation between the actual diopter of the lens and the diopter equivalent calculated by the software. The average difference between the actual and predicted values was 0.04 diopters.



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