Sensing Dust Concentration by Imaging

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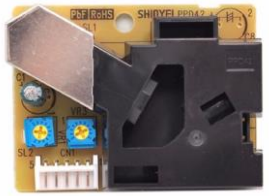
Sensing dust concentration

- Examples of Existing Dust concentration Sensing/Measurement:
  - Counting/weighing (IR/reflection)

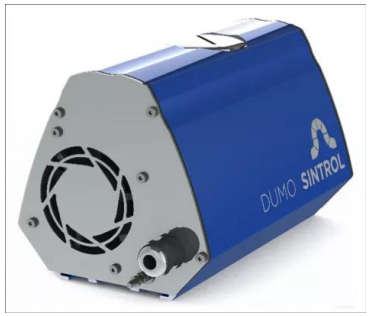


Grove-dust sensor

  - Triboelectric

AirSafe – Continuous dust monitoring

  - Electrostatic induction



Sintrol Dumo EXG A

Novelty: Real-time monitoring and/or instantaneous dust concentration measurement by imaging.

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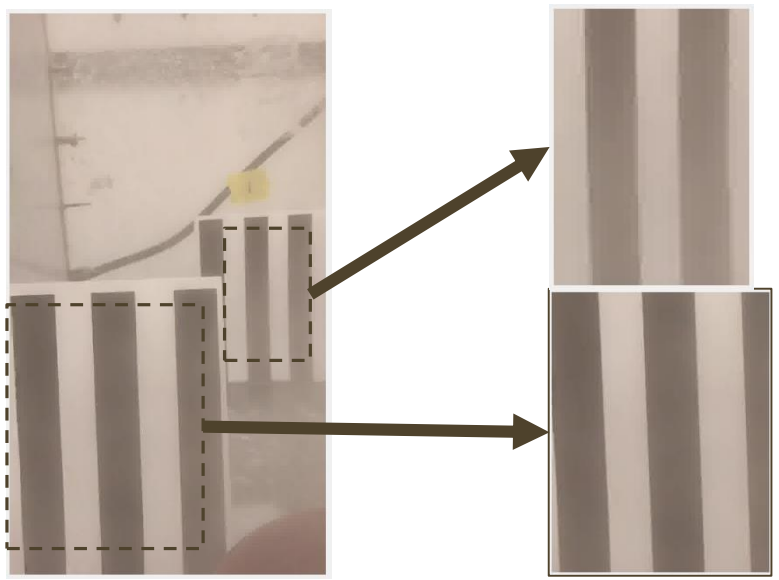
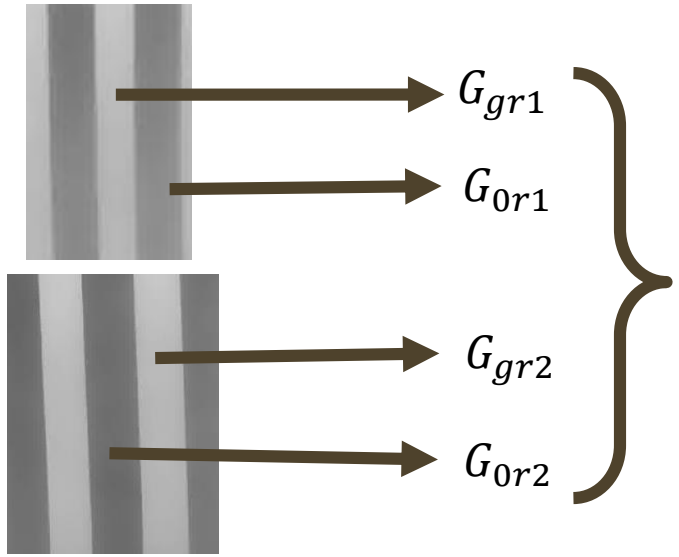
Plan



1. Crop target from image

2. Convert RGB to HSV, obtain intensity value of each pixel



3. Using Otsu filter to separate black & white backgrounds, obtain the average intensity value (G)

$$\varepsilon = \frac{\ln\left(\frac{G_{0r1} - G_{gr1}}{G_{0r2} - G_{gr2}}\right)}{R1 - R2}$$

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Method

- Atmospheric scattering model: (the light intensity of target detected by the detector at distance R) (Sun, et al., 2005)

$$J_{0r} = J_0 e^{-\int_0^R -\varepsilon(r)dr} + J_A(1 - e^{-\int_0^R -\varepsilon(r)dr})$$

$$J_{gr} = J_g e^{-\int_0^R -\varepsilon(r)dr} + J_A(1 - e^{-\int_0^R -\varepsilon(r)dr})$$

J_{0r} is the observed target light intensity; J_0 is the real target light intensity;

J_{gr} is the observed background light intensity; J_g is the real background light intensity;

J_A is the atmospheric light; ε is the total extinction coefficient;

R is the distance from point of observation to target.

- Extinction coefficient, $\varepsilon = \frac{\ln\left(\frac{J_{0r}-J_{gr}}{J_0-J_g}\right)}{R}$ $\varepsilon = \frac{\ln\left(\frac{G_{0r1}-G_{gr1}}{G_{0r2}-G_{gr2}}\right)}{R1-R2}$
- Mass concentration, $C = \frac{2d_p\rho}{3q} \cdot \varepsilon$ (C in kg/m^3) (Ogle, 2016)

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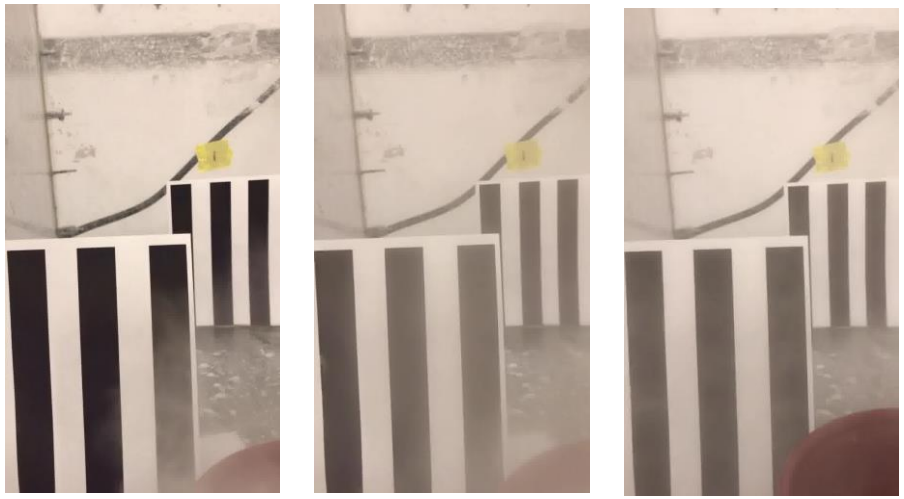
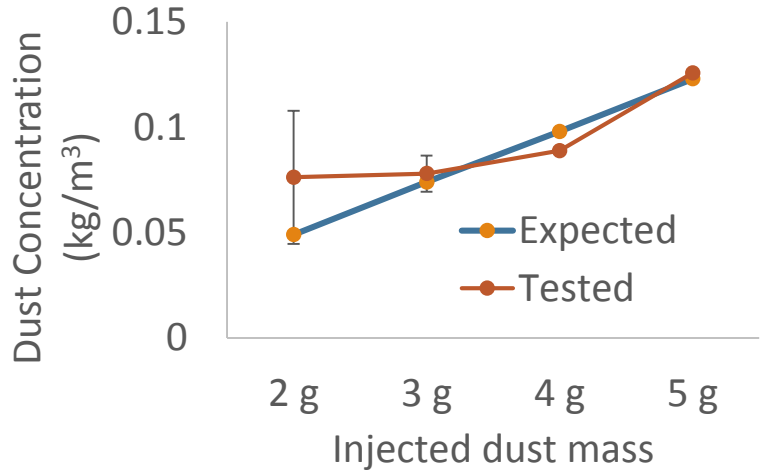
Preliminary experiment results

Extracted image:



0.025 kg/m^3



0.075 kg/m^3

Proposal Objectives/Work Plan

Objectives:

- To sense dust concentrations using particle extinction coefficient
- To develop a smart-phone app to monitor dust concentration

Applications

- Any confined space
- Turbulent locations

Work plan

- Sample: corn starch (will be expanded to other dusts)
- Build upon the preliminary tests/trials to develop an accurate correlation (year 1)
- Develop a mobile app that could be directly used without any training (year 2)

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