These equations will be used in the offline analysis contained within the image analysis controller

$$\mu_x = \frac{1}{\sum v_i} \sum v_i * x_i$$

$$\mu_y = \frac{1}{\sum v_i} \sum v_i * y_i$$

$$\sigma_x{}^2 = \frac{1}{\sum v_i} \sum v_i * (x_i - \mu_x)^2$$

$$\sigma_y{}^2 = \frac{1}{\sum v_i} \sum v_i * (xy_i - \mu_y)^2$$

$$\mathrm{Cov}_{xy} = \frac{1}{\sum v_i} \sum v_i * (xy_i - \mu_y) * (x_i - \mu_x)$$

Error propagation uses the following equation (for a function f(a,b), where a and b are independent of each other):

$$\sigma_f{}^2 = \left(\frac{\partial f}{\partial a}\right)^2 \sigma_a{}^2 + \left(\frac{\partial f}{\partial b}\right)^2 \sigma_b{}^2 \qquad (1)$$

Using the above equat the error for $\frac{1}{\sum v_i}$ is:

$$f = \frac{1}{\sum v_i}$$

$$\sigma_f{}^2 = \sum \left(\frac{\partial f}{\partial v_i}\right)^2 \sigma_i{}^2 = \sum \sigma_i{}^2$$

$$\sigma_f = \sqrt{\sum \sigma_i{}^2}$$

Error Propagation for μ_x:

$$\sigma_{\mu_x}{}^2 = \left(\frac{\partial \mu_x}{\partial f}\right)^2 \sigma_f{}^2 + \sum \left(\frac{\partial \mu_x}{\partial v_i}\right)^2 \sigma_{v_i}{}^2$$

$$= \left(\frac{-\mu_x}{f}\right)^2 \sigma_f{}^2 + \sum \left(\frac{x_i}{f}\right)^2 \sigma_{v_i}{}^2$$

Error Propagation for μ_x:

$$\sigma_{\mu_y}{}^2 = \left(\frac{\partial \mu_y}{\partial f}\right)^2 \sigma_f{}^2 + \sum \left(\frac{\partial \mu_y}{\partial v_i}\right)^2 \sigma_{v_i}{}^2$$

$$= \left(\frac{-\mu_y}{f}\right)^2 \sigma_f{}^2 + \sum \left(\frac{y_i}{f}\right)^2 \sigma_{v_i}{}^2$$

Error Propagation for σ_x:

$$\sigma_{\sigma_x{}^2}{}^2 = \left(\frac{\partial \sigma_x{}^2}{\partial f}\right)^2 \sigma_f{}^2 + \left(\frac{\partial \sigma_x{}^2}{\partial \mu_x}\right)^2 \sigma_{\mu_x}{}^2 + \sum \left(\frac{\partial \sigma_x{}^2}{\partial v_i}\right)^2 \sigma_{v_i}{}^2$$

$$= \left(\frac{-\sigma_x{}^2}{f}\right)^2 \sigma_f{}^2 + \left(\frac{-2}{f} \sum v_i * (x_i - \mu_x)\right)^2 \sigma_{\mu_x}{}^2 + \sum \left(\frac{(x_i - \mu_x)^2}{f}\right)^2 \sigma_{v_i}{}^2$$

Error Propagation for σ_y:

$$\sigma_{\sigma_y{}^2}{}^2 = \left(\frac{\partial \sigma_y{}^2}{\partial f}\right)^2 \sigma_f{}^2 + \left(\frac{\partial \sigma_y{}^2}{\partial \mu_y}\right)^2 \sigma_{\mu_y}{}^2 + \sum \left(\frac{\partial \sigma_y{}^2}{\partial v_i}\right)^2 \sigma_{v_i}{}^2$$

$$= \left(\frac{-\sigma_y{}^2}{f}\right)^2 \sigma_f{}^2 + \left(\frac{-2}{f} \sum v_i * (y_i - \mu_y)\right)^2 \sigma_{\mu_y}{}^2 + \sum \left(\frac{(y_i - \mu_y)^2}{f}\right)^2 \sigma_{v_i}{}^2$$

Error Propagation for Cov_{xy}:

$$\sigma_{Cov_{xy}}{}^2 = \left(\frac{\partial Cov_{xy}}{\partial f}\right)^2 \sigma_f{}^2 + \left(\frac{\partial Cov_{xy}}{\partial \mu_x}\right)^2 \sigma_{\mu_x}{}^2 + \left(\frac{\partial Cov_{xy}}{\partial \mu_y}\right)^2 \sigma_{\mu_y}{}^2 + \sum \left(\frac{\partial Cov_{xy}}{\partial v_i}\right)^2 \sigma_{v_i}{}^2$$

$$= \left(\frac{-Cov_{xy}}{f}\right)^2 \sigma_f{}^2 + \left(\frac{-1}{f} \sum v_i * (y_i - \mu_y)\right)^2 \sigma_{\mu_x}{}^2 +$$
$$\left(\frac{-1}{f} \sum v_i * (x_i - \mu_x)\right)^2 \sigma_{\mu_y}{}^2 + \sum \left(\frac{(y_i - \mu_y)\ (x_i - \mu_x)}{f}\right)^2 \sigma_{v_i}{}^2$$