Continuous Buhmbox Formulation

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Buhmbox generalization to continuous phenotypes - no cases and controls

Assuming normalized weights ($\sum \omega_i = 1$), we define the weighted mean as:

$$m(x, \omega) = \sum_i \omega_i x_i$$

The weighted covariance as:

$$cov(x, y, \omega) = \sum_i w_i(x_i - m(x, \omega))(y_i - m(y, \omega))$$

Finally we have that the weighted correlation is given by:

$$corr(x, y, \omega) = \frac{cov(x, y, \omega)}{\sqrt{cov(x, x, \omega)cov(y, y, \omega)}}$$

Assume we are given N data points (each data point corresponds to an individual's SNPs, $x_i \in \mathbb{R}$, and his phenotype, $y_i \in \mathbb{R}$). We have to further assume that the sample is representative of the population.

We then use $w_i = -log(1 - \rho_i)$ where ρ_i is the percentile of data point $x_i's$ phenotype (and then normalize the w_i's to have $\sum w_i = 1$). We also let R be the weighted covariance matrix and R' be the unweighted covariance matrix. Then we use:

$$Y = \frac{1}{\sqrt{\frac{1}{N} + \sum \omega_i^2}}(R - R')$$

$$S_{\text{BUHMBOX}} = \frac{\sum_{i<j} w_{ij} y_{ij}}{\sqrt{\sum_{i<j} w_{ij}^2}}$$

Where we have

$$w_{ij} = \frac{\sqrt{p_i(1 - p_i)p_j(1 - p_j)}(\gamma_i - 1)(\gamma_j - 1)}{((\gamma_i - 1)p_i + 1)((\gamma_j - 1)p_j + 1)}$$

Where p_i is the RAF of SNP i and γ_i is given by: $\gamma_i = \frac{(p_i^+)(1-p_i^+)}{(p_i^-)(1-p_i^-)}$ where p_i^+ is the weighted sample RAF (using ω weights) and p_i^- is the unweighted sample RAF.