A Direct Approach to False Discovery Rates

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ERRATA (as of 4/16/03):

• The following assumptions are made throughout the paper. These are stated in the paper, but unfortunately not very clearly. We assume that m hypothesis tests are performed based on corresponding p-values $P_1, P_2, \ldots, P_m$. The realized versions of these p-values are written as $p_1, p_2, \ldots, p_m$. Let $H_i = 0$ if null hypothesis i is true and $H_i = 1$ if it is false, $i = 1, 2, \ldots, m$. We assume that $(P_1, H_1), (P_2, H_2), \ldots, (P_m, H_m)$ are i.i.d. random variables such that $P_i|H_i = 0$ is Uniform(0,1) and $P_i|H_i = 1$ has continuous probability density function $g(\cdot)$. The H_i are marginally i.i.d. Bernoulli random variables such that $\mathbf{Pr}(H_i = 0) = \pi_0$ and $\Pr(H_i = 1) = \pi_1 = 1 - \pi_0$. It is reasonable to assume that $P_i|H_i = 1$ is stochastically smaller that $P_i|H_i = 0$, although this assumption is not always necessary.

• Page 479, Line -6: The FWER was not necessarily the first multiple hypothesis testing error measure used, but it has been used for many years.

• Page 485, Line +4: This entire paragraph should read:

> "Suppose that we enforce the reasonable constraint that $\widehat{\pi}_0 \leq 1$. The basic point we make here is that using the Benjamini and Hochberg (1995) method to control the FDR at level $\alpha/\widehat{\pi}_0$ is equivalent to (i.e., calls the same p-values significant as) using the proposed method to control the FDR at level α. The gain in power from our approach is clear – we control a smaller error rate ($\alpha \leq \alpha/\widehat{\pi}_0$), yet reject the same number of null hypotheses."

• Page 489, Line -6: This sentence should read: "In situations where g is unknown but Corollary 1 holds with $g'(1) = 0$, this estimate is loosely speaking 'optimal' in that the bias can usually be made arbitrarily small while obtaining the smallest asymptotic variance (according to standard mle theory) for each λ."

• Page 492, Section 9: This section in general uses sloppy terminology and (unintentionally) makes exaggerated claims. The section is not about "calculating the optimal λ" but rather about "estimating the λ that minimizes the mean-squared error." Therefore, the proposed method calculates an estimate based on a particular criterion that I have labelled as optimal. In later work, others and I have considered other criteria. The important property of Section 9, however, is that I attempt to take into account the variance of a multiple hypothesis testing procedure, which I believe had not been previously considered.