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4.3.6 Problem Set: p-norm approximation of minimums and maximums

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Because use of min and max functions causes discontinuous derivatives, we will instead use a p-norm approximation of these functions. Specifically, consider a vector $\underline{v}$ which has K entries, $\underline{v} = [v_0, v_1, \ldots, v_{K-1}]$. Then define the following p-norms:

$$\mathrm{pmin}\,(\underline{v}) = \left[\frac{1}{K}\sum_{k=0}^{K-1} |v_k|^{-p}\right]^{-1/p} \tag{4.48}$$

$$\mathrm{pmax}\,(\underline{v}) = \left[\frac{1}{K}\sum_{k=0}^{K-1} |v_k|^{p}\right]^{1/p} \tag{4.49}$$

Note that as $p \to \infty$, then $\mathrm{pmin}\,(\underline{v}) \to \min\,(\underline{v})$ and $\mathrm{pmax}\,(\underline{v}) \to \max\,(\underline{v})$.

In our particular problem, we wish to use the combination of $\min\max$ in our objective function. Specifically, for the power between N_u users and N_b bases, this objective using p-norms can be shown to be:

$$J_p = -\left\{\frac{1}{N^u}\sum_j \left[\frac{1}{N^b}\sum_i (P_{ij})^p\right]^{-1}\right\}^{-1/p} \tag{4.50}$$

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