



## Why

We want to estimate a random vector  $x : \Omega \rightarrow \mathbf{R}^d$  from a random vector  $y : \Omega \rightarrow \mathbf{R}^n$ .

## Definition

Denote by  $g : \mathbf{R}^d \times \mathbf{R}^n \rightarrow \mathbf{R}$  the joint density for  $(x, y)$ .<sup>1</sup> Denote the conditional density for  $x$  given  $y$  by  $g_{x|y} : \mathbf{R}^d \times \mathbf{R}^n \rightarrow \mathbf{R}$ . In this setting,  $g_{x|y}$  is called the *posterior density*,  $g_x$  is called the *prior density*, and  $g_{y|x}$  is called the *likelihood density* and  $g_y$  is called the *marginal likelihood density*.

As usual (and assuming  $g_y > 0$ ), the posterior is related to the likelihood, prior and marginal likelihood by

$$g_{x|y} \equiv \frac{g_x g_{y|x}}{g_y}.$$

A *maximum conditional estimate* for  $x : \Omega \rightarrow \mathbf{R}^n$  given that  $y$  has taken the value  $\gamma \in \mathbf{R}^n$  is a maximizer  $\xi \in \mathbf{R}^d$  of  $g_{x|y}(\xi, \gamma)$ . It is also called the *maximum a posteriori estimate* or *MAP estimate*. The maximum conditional estimate is natural, in part, because it also maximizes the joint density, since  $g(\xi, \gamma) = g_y(\gamma)g_{x|y}(\xi, \gamma)$  for all  $\xi \in \mathbf{R}^d$  and  $\gamma \in \mathbf{R}^n$ .

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<sup>1</sup>Future editions will comment on the existence of such a density.



