Towards a neural model of prediction and uncertainty

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The fact that the brain performs some kind of inference to make predictions and understand the world is a theory that has been growing in the latest years. Nonetheless, these functional theories fail to address how predictions could actually be implemented in biological brains. We derive here a mathematical implementation of such predictions that can be easily implemented as a neural network. By using gradient descent optimization methods, we derive the mathematical formulation to train a graphical model to perform statistical inference. The derivation of our model can be interpreted as a network of neurons and leads to local learning rules that can be derived from and compared to classical Hebbian learning rules. This model provides a biologically plausible implementation of statistical inference, that allows the computation of expected values and standard deviations in a neural circuit. Moreover, the uncertainty or confidence on such predictions can be extracted from the model with minimal extensions. We test the capabilities of the model in continuous function estimation and discrete classification tasks. Interestingly, our framework draws resemblance to the cortical microcircuitry, promoting a reinterpretation of the role of inhibitory interneurons and neuromodulators such as acetylcholine. All together, our model is a first step towards bridging the gap between functions and mechanisms for prediction in the brain.

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