Role of Feedback in Visual Information Processing

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The convolutional neural networks (CNN) have seen spectacular success in tasks like object recognition in recent years. The structure of CNNs, characterized by local connectivity, weight sharing, and multiple filters, is quite effective in learning many local features at different scales through feedforward connection of multiple convolutional layers. The structure is inspired by and is quite similar to the structure of the mammalian visual system. There are studies that show remarkable similarities in the filters learnt by CNNs and those in some areas of the mammalian visual system. However, one important aspect in which the analogy between CNNs and the biological visual system breaks down, is in the fact that there are massive feedback connections between multiple areas in biological vision. The role played by the feedback connections in biological visual information processing is not well understood though there have been many hypotheses and studies over the last two decades. Recently researchers started studying the utility of feedback in CNN models too. This project seeks to investigate some general mechanisms of feedback models for CNNs, study their biological plausibility and through them gain some understanding of the utility of feedback in the mammalian visual system. The present generation of CNNs are rather brittle and are very susceptible to certain kinds of noise which our vision system seems to be robust to. One of the aspects of study in this project would be to understand how the feedback may allow the system to properly assess available (possibly conflicting) evidences gathered through bottom-up processing against expectation-based top-down processing driven by feedback. The project seeks to evolve some biologically plausible feedback models for expectation-driven processing. Other aspects of feedback that would investigated include its utility in learning input-dependent selection of relevant filters during inference, evolving locality of connections in filter domain and learning of global features which can help in being immune to adversarial noise. The project would involve developing feedback-based CNN models as well as studying biologically plausible mechanisms for feedback.