Capturing Broad Temporal Dependencies in Deep-Layer Networks

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Shallow pattern inference systems necessitate a pre-processing stage whereby high-dimensional signals are mapped to a lower-dimension feature space that can be applied to standard classifiers. As a result, the intelligence of the system shifts to the feature extraction process, which is often imperfect and always application-domain specific. Deep machine learning [1] has emerged as a promising framework for dealing with complex, high-dimensional data, in a natural data-driven way. These systems form a hierarchical feature space that is driven by regularities in the observations, rather than by hand-crafted techniques.

While methods such as Deep belief networks [2] and Convolutional Neural Networks [3] have been successfully demonstrated to address pattern recognition in high-dimensional data (e.g. large images), there remains a need for an architecture that can represent temporal information with the same ease in which spatial structure is discovered. The Deep Spatiotemporal Inference Network (DeSTIN) architecture [4] yields a highly scalable information representation framework which is capable of effectively dealing with high-dimensional signals. The architecture comprises of a basic cortical circuit (or node) which homogeneously populates all layers of the hierarchy. Each node inherently represents both spatial and temporal information pertaining to its observations via a belief state construct. This is achieved by means of two complementing mechanisms: a dynamic Bayesian model and spatiotemporal clustering, both of which are learned online. The lower layers of the hierarchy represent shorter temporal dependencies, while higher layers pertain to longer-term temporal information. Hence, for both spatial and temporal features, as one ascends the hierarchy scope if gained and detail is lost.

We demonstrate that information from the DeSTIN system can be extracted and utilized for the purpose of robust dynamic pattern classification. Our simulation results indicate that the framework offers the potential to solve large-scale, real-world machine learning problems relating to behavior analysis, speech processing and multi-modal data fusion.

References

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