# Symbolic Neural Networks

A symbolic neural network is a type of neural network architecture that incorporates both sub-symbolic and symbolic processing. In a symbolic neural network, sub-symbolic processing is used for low-level perceptual processing, while symbolic processing is used for higher-level reasoning and decision-making.

Symbolic processing involves the manipulation of symbolic representations, such as rules, concepts, and symbols. This type of processing is often used in artificial intelligence applications for tasks such as reasoning, planning, and problem-solving.

In a symbolic neural network, sub-symbolic processing is typically implemented using a connectionist architecture, such as a feedforward or recurrent neural network, while symbolic processing is often implemented using a rule-based system or other symbolic processing techniques.

The combination of these two types of processing allows symbolic neural networks to reason about complex, abstract concepts while still being able to learn from raw sensory data. This makes them well-suited for tasks that require both high-level reasoning and low-level sensory processing, such as language understanding and image recognition.

## CNN

There are variants of CNNs that incorporate symbolic processing to some extent. For example, the concept of attention, which involves selectively focusing on certain regions of an image or sequence, can be seen as a form of symbolic processing. There are also hybrid neural network architectures that combine CNNs with symbolic reasoning systems, such as the Neural-Symbolic Cognitive Reasoning (NSCR) framework.

Attention is a mechanism used in deep learning that allows a neural network to selectively focus on certain regions of an input, such as an image or a sequence of text. By focusing on certain regions, the network can better capture important information and ignore irrelevant details.

In a typical attention mechanism, the network is designed to learn a set of attention weights, which are used to weigh different parts of the input. These weights are often learned using a separate neural network that takes the input as input and outputs the attention weights.

The attention mechanism can be seen as a form of symbolic processing because it involves the selective focusing of attention based on some rule or criteria. In this case, the rule is the learned attention weights. These weights can be thought of as symbolic representations that allow the network to selectively process certain regions of the input.

The Neural-Symbolic Cognitive Reasoning (NSCR) framework is an example of a hybrid neural network architecture that combines convolutional neural networks (CNNs) with symbolic reasoning systems. In the NSCR framework, the input is first processed by a CNN to extract features, and then the features are passed to a symbolic reasoning system that performs logical operations on the features.

The symbolic reasoning system in the NSCR framework is designed to operate on symbolic representations, such as rules and logical statements, which allows it to reason about complex relationships and make inferences. The combination of the sub-symbolic processing of the CNN and the symbolic processing of the reasoning system allows the NSCR framework to perform complex cognitive tasks, such as language understanding and visual reasoning.

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## NSCR

The Neural-Symbolic Cognitive Reasoning (NSCR) framework is a hybrid neural network architecture that combines sub-symbolic processing with symbolic processing to enable the network to perform complex cognitive tasks, such as language understanding, visual reasoning, and decision-making.

The NSCR framework is composed of three main components: a feature extraction network, a symbolic reasoning system, and a decision-making module. Here is a brief overview of each component:

Feature extraction network: This component is typically a convolutional neural network (CNN) that is used to extract features from raw sensory data, such as images or audio. The output of the CNN is a set of feature vectors that represent the input data.

Symbolic reasoning system: This component is a rule-based system that performs logical operations on the feature vectors to enable the network to reason about complex relationships and make inferences. The symbolic reasoning system can be designed to operate on different types of symbolic representations, such as rules, logical statements, or first-order logic.

Decision-making module: This component uses the output of the symbolic reasoning system to make a decision, such as choosing the correct answer to a question or performing a specific action.

## STEPS

* Learn the basics of deep learning and neural networks: Before diving into NSCR, it is important to have a solid understanding of the fundamentals of deep learning and neural networks. This includes understanding the basic building blocks of neural networks, such as neurons, layers, and activation functions, as well as the various types of neural networks, such as CNNs and recurrent neural networks (RNNs).
* Learn about symbolic processing and reasoning: To understand the symbolic reasoning system in NSCR, it is important to have a basic understanding of symbolic processing and reasoning. This includes learning about logic, reasoning, and rule-based systems.
* Study NSCR research papers and implementations: There are several research papers and implementations of the NSCR framework available online that you can study to learn more about the framework. Some papers to start with include "Neural-Symbolic Cognitive Reasoning" by Xiaodan Liang et al. and "Neural-Symbolic VQA: Disentangling Reasoning from Vision and Language Understanding" by Haejun Lee et al.
* Practice with NSCR tools and libraries: There are several tools and libraries available that can help you experiment with the NSCR framework. These include the Neural-Symbolic Learning and Reasoning (NSLR) library and the TensorFlow implementation of NSCR.
* Experiment with NSCR on your own projects: Once you have a basic understanding of NSCR, you can start experimenting with the framework on your own projects. This can include tasks such as visual question answering, natural language processing, and decision-making.

## Project: Visual Question Answering with NSCR

The goal of this project is to build an NSCR system that can answer natural language questions about visual scenes. Specifically, the system will take as input an image and a natural language question, and output an answer to the question.

* Data collection: The first step is to collect a dataset of images and corresponding questions and answers. There are several existing datasets that can be used for this task, such as the VQA dataset or the CLEVR dataset.
* Data preprocessing: The next step is to preprocess the dataset so that it can be used as input to the NSCR system. This may include resizing images, tokenizing questions, and encoding answers.
* Feature extraction: The input to the NSCR system is a set of feature vectors that represent the image and the question. The image features can be extracted using a pre-trained CNN, such as ResNet or Inception, while the question features can be generated using a natural language processing (NLP) model, such as BERT or GPT.
* Symbolic reasoning: The feature vectors are then passed to the symbolic reasoning system, which performs logical operations on the features to enable the network to reason about the relationship between the image and the question. This may involve defining rules or logical statements that encode common sense knowledge about the world.
* Decision-making: The output of the symbolic reasoning system is a set of candidate answers to the question. The decision-making module then selects the most likely answer based on the reasoning process.
* Training and evaluation: The NSCR system is trained on the dataset using a supervised learning approach, where the model is optimized to minimize a loss function that measures the error between the predicted answers and the ground truth answers. The model is then evaluated on a held-out test set to measure its performance.
* Improvement: Once the NSCR system is working, there are several ways to improve its performance. This may involve fine-tuning the pre-trained CNN or NLP model, adding more rules or logical statements to the reasoning system, or experimenting with different decision-making strategies.