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研究課題名（和文）Evolutionary Approaches to Learning Self-awareness for a Decentralized System

研究課題名（英文）Evolutionary Approaches to Learning Self-awareness for a Decentralized System

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交付決定額（研究期間全体）：（直接経費）　　3,200,000円

研究成果の概要（和文）：自己認識ニューラルネットワークサブシステムのセットを備えた分散型認識システムが開発されている。認識されたニューラルネットワークは、その状態、行動、および性能を認識することにより、学習されたデータの正しい表現をよりよく得ることができる。彼らは、分散型学習システム全体を通じてコンテキスト情報を配布することができます。差別学習と有界学習を用いた負の相関学習によって、分散型学習システムでは2つのレベルの自己認識が作成されています。
　認識ニューラルネットワークは、医療データと金融データの両方のアプリケーションでよりよく学習できます。研究成果は発表され、いくつかの国際会議で発表されました。

研究成果の概要（英文）：A decentralized awareness system with a set of self-aware neural network subsystems has been developed in this project. Awareness neural networks of being aware of their states, behavior and performance can better acquire the right representations of the learned data. They are able to distribute context information through the whole decentralized learning system.
　Two levels of self-awareness have been created in the decentralized learning system by negative correlation learning with difference learning and the bounded learning. They are private self-awareness for individual neural networks and public self-awareness for the decentralized learning system.
　Awareness neural networks could better meet their requirements for predictions in the applications on both medical and financial data. The research results have been published in the international journals, and presented in a number of international conferences.

研究分野：機械学習

キーワード：機械学習　統計学習　計算知能　人工ニューラルネットワーク　データマイニング

１．研究開始当初の背景

Although neural network learning has demonstrated some remarkable success in the applications of speech and image recognition, design of neural network architectures still suffers from time consuming training processes because it often involves many retraining processes on big data if the trained neural network architectures are not sufficient to model the data. It is quite common to take days to months of time on hundreds of machines to train neural networks for a single application. In the last decade, neural networks have doubled in size roughly every 2.4 years, which have been driven by the improved computer infrastructures and the faster growing datasets.

With such trend of the increasing model size in neural network learning, a neural network learning system should be able to grow itself online in the learning. A decentralized learning system with a set of self-aware neural network subsystems has been proposed in this project, which is able to solve a complex task more satisfactorily by learning to subdivide the task.

２．研究の目的

This project is to develop a methodology for designing a decentralized learning system with a set of self-aware neural network subsystems. The hypothesis adopted in this project implies that systems being aware of their own state, behavior and performance can manage trade-offs between goals at run-time. Such self-awareness enables systems to better meet their requirements in uncertain and dynamic environments.

３．研究の方法

Two levels of self-awareness have been created in the decentralized learning system in which there are private self-awareness for individual neural networks and public self-awareness for the decentralized system.

Private self-awareness is trained by negative correlation learning with difference learning in which two different learning functions on the two separated subsets have been implemented in order for each individual neural network to adapt its learning direction on a given data sample so that all neural networks could be aware of others, and cooperative each other.

Public self-awareness at the ensemble level is created by the selectively and bounded negative correlation learning. Negative correlation learning is able to learn interaction and cooperation among individual neural networks in a decentralized system, and uses an unsupervised term in learning functions to produce negatively correlated neural networks.

４．研究成果

In 2015, two learning methods were developed, including difference learning and the bounded learning. The idea of difference learning is to let each neural network in an ensemble learn to be different to the ensemble on some

selected data points when the outputs of the ensemble are too close to the target values of these data points. It has been found that such difference learning could control not only overfitting in an ensemble, but also weakness among the individual neural networks in the ensemble. Experimental results were conducted to show how such difference learning could create rather weak neural networks in negative correlation learning.

Two error bounds are introduced into the bounded negative correlation learning for the better performance. One is the upper bound of error output which divides the training data into two groups based on the distances between the data and the formed decision boundary. The other is the lower bound of error rate which is set as a learning switch. Before the performance measured by error rates is higher than the lower bound of error rate, negative correlation learning is applied on the whole training set. As soon as the performance is lower than the lower bound of error rate, negative correlation learning will only be applied to the group of data whose distances to the current decision boundary are within the range of the upper bound of error output. The other group of data outside of this range will not be learned anymore. Further learning on the data points in the other group would make the learned decision boundary too complex to classify the unseen data well. Experimental results were explored how error bounds would lead negative correlation learning towards a robust decision boundary.

In 2016, two different negative selections were introduced in negative correlation learning for letting individual neural networks be able to adapt the learning error functions in the whole learning process. The first negative selection is based on the opposition learning, while the second negative selection is through difference learning. On one hand, when the learning would force one neural network to be closer to the other neural networks in the learning system, it would choose to learn less so that the learning on that direction would not be encouraged. On the other hand, when the learning would help one neural network to be more different to the others, it would let itself to learn more so that the learning on that direction would be encouraged.

In 2017, an integrated negative correlation learning system was applied, in which each individual neural network in an neural network ensemble would either learn a data point by negative correlation learning or learn to be different to the neural network ensemble. The implementation is through randomly splitting the training set into two subsets for each individual neural network in learning. On one subset of the training data, the individual neural network would be trained by negative correlation learning. On the other subset of the training data, the individual neural network would be trained to be different to the neural network ensemble. The purpose of such random splitting of the training data is

to allow each individual neural network to build up its self-awareness of the learning direction on each given data point.

Experimental results have shown that awareness neural networks by negative correlation learning could better meet their requirements for predictions in the applications on both medical and financial data. The research results have been published in the international journals, and presented in a number of international conferences.

５．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

〔雑誌論文〕（計　3　件）

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〔産業財産権〕

○出願状況（計　0　件）

名称：
発明者：
権利者：
種類：
番号：
出願年月日：
国内外の別：

○取得状況（計　0　件）

名称：
発明者：
権利者：
種類：
番号：
取得年月日：
国内外の別：

〔その他〕
ホームページ等

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