Evolving Machine Learning Paradigm In BCI And Person Re-Identification

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Abstract*- Machine learning is one of the most promising artificial intelligence tools. Similarity learning is an area of supervised machine learning in artificial intelligence. The goal is to learn from examples a similarity function that measures how similar or related two objects are. Further, state-of-the-art brain–computer interface (BCI) powered with machine learning backbones the technology used in unmanned aerial vehicles. Our goal is to assist the readers in refining the motivation, problem formulation, and methodology of powerful machine learning algorithms in order to tap into hitherto unexplored applications and services.*

Keywords- user centric, machine learning system, similarity learning,

I. INTRODUCTION

Machine learning has found wide-ranging applications in image/audio processing, finance and economics, social behaviour analysis, project management, and so on. Explicitly, a machine learns the execution of a particular task T, with the goal of maintaining a specific performance metric P, based on a particular experience E, where the system aims to reliably improve its performance P while executing task T, again by exploiting its experience E. Depending on how we specify T, P, and E, the learning might also be referred to as data mining, autonomous discovery, database updating, programming by example, and so on.

Machine learning algorithms can be simply categorized as supervised and unsupervised learning, where the adjectives “supervised/unsupervised” indicate whether there are labelled samples in the database. Later, reinforcement learning emerged as a new category that was inspired by behavioural psychology. It is concerned with an agent’s certain form of reward/utility, who is connected to its environment via perception and action. The family of machine learning algorithms can also be categorized based on their similarity in terms of their functionality and structure, yielding regression algorithms, instance-based algorithms, regularization algorithms, decision tree algorithms, Bayesian algorithms, clustering algorithms, association rule based learning algorithms, artificial neural networks, deep learning, algorithms dimension reduction algorithms, ensemble algorithms, and so on. In this article, we will introduce the basic concept of machine learning algorithms and the corresponding applications according to the category of supervised, unsupervised, and reinforcement learning.

II. SIMILARITY LEARNING WITH LISTWISE RANKING FOR PERSON RE-IDENTIFICATION

Person re-identification is the problem of identifying people across images that have been captured by different surveillance cameras without overlapping fields of view. The task is receiving increasing attention because of its important applications in video surveillance such as cross-camera tracking, multi-camera behavior analysis and forensic search.It consists in matching an image of a probe person among a gallery image set of people detected from a network of surveillance cameras with non-overlapping fields of view. The main challenge of person re-identification is to find image representations that are discriminating the persons identities and that are robust to the viewpoint, body pose, illumination changes and partial occlusions. This problem is challenging due to the large variations of lighting, pose, viewpoint and background. The images from the same individual can have very different appearance and different individuals may look similar in appearance.

Existing person re-identification approaches generally build a robust feature representation or learn a distance metric. With the recent success of deep learning for computer vision, many deep convolutional neural network (CNN) architectures have been proposed for person re-identification. These deep learning models incorporate feature representation and distance metric into an integrated framework. To learn the features and the metric, different loss functions have been proposed such as contrastive loss, triplet loss or quadruplet loss.

III. APPLICATIONS

Learning-to-rank is a class of techniques that learns a model for optimal ordering of a list of items. It is widely applied in information retrieval and natural language processing. LambdaRank is an improved learning-to-rank method based on RankNet. RankNet uses a neural network with a pair-based cross entropy cost. It is optimizing for the number of pairwise errors, which does not consider with some other information retrieval measures. However, the evaluation measures are not differentiable. Thus, they cannot directly be incorporated in the optimization. To tackle this problem, LambdaRank was proposed which simply scales the gradient of the loss function by the difference of the evaluation measure incurred by swapping the rank positions of two items, and they show an improvement of the overall ranking performance. In triplet learning for person re-identification, we face a similar problem. The classical triplet loss is defined on the partial order relations among identities, however, the ranking measures are calculated on the global order. That means that the triplet loss iteratively enforces pair-wise order relationships w.r.t. reference examples, but it is difficult to generalize this approach for optimizing the global order. In this regard, a listwise ranking is a better approximation of this global order relation.The triplet loss uses triplets of examples to train the network with an anchor image a, a positive image p from the same person as a and a negative image n from a different person. The weights of the network for the three input images are shared, and to train the network, the triplet loss function is minimised.With the triplet loss function, the network learns a semantic distance metric by ”pushing” the negative image pairs apart and ”pulling” the positive images closer in the feature space. This evaluation measure-based weighting makes better use of difficult triplets which can bring a larger rank improvement and are more effective for the learning, and at the same time, keep the learning stable by using all mis-ranked pairs, since only using the hardest examples can in practice lead to bad local minima early in training.

Compared to different losses, the Rank-Triplet loss gives a better performance. The improvement w.r.t. the baseline showed the effectiveness of the listwise evaluation measure-based weighting. This demonstrates that hard example mining could make the learning more effective, but some too hard examples may severely perturb the learning procedure. The proposed approach using Rank-Triplet loss outperforms most state-of-art methods. By combining it with the re-ranking techniques in the approach achieves state-of-the-art results.

IV. UNMANNED AERIAL VEHICLE REMOTE CONTROL USING BCI

DEVELOPING a direct communication pathway between the human brain and the outside world is a distinguished concept. Technology developed over the past two decades has allowed for the implementation of brain-computer interface (BCI), which is an outstanding innovation for recording and translating brain signals into control commands for robotic systems. Although BCI research is still in its early stages, it has been proven effective in a wide range of applications, and has thus gained significant momentum over the past few years [1]. BCI studies have primarily focused on developing rehabilitation systems to help those suffering from devastating neuromuscular disorders or chronic trauma such as amyotrophic lateral sclerosis, epilepsy, and brainstem stroke. Virtual keyboard and the P300 speller are among the well-established, BCI-based devices that have provided functional means of communication for patients with locked-in syndrome or other forms of aphasia. Moreover, BCI has catered a revolutionary framework that allows for the engineering of real-time, brain-controlled robotic systems. This includes assistive devices that are intended for people with disabilities, such as wheelchairs and prosthetic limbs, and other robotic systems that are developed to serve healthy people on a daily basis. Unmanned aerial vehicles (UAVs) is a quintessential technology in this regard, which is also experiencing a spike in interest. There has been a drastic increase of importance for the various applications of drones in recent times due to their unprecedented role in performing aerial operations, where the presence of a pilot is not possible.
Current state-of-the-art BCI is facing fundamental technical challenges and limitations—this dictates major restrictions on the functionality of systems that incorporate BCI in their design. From a practical perspective, there are other control modalities that substantially outperform BCI in respect to the robustness and fidelity. These control modality use machine learning techniques to address the various BCI limitations.

V. APPLICATIONS

“Actionable Data” is next to a powerful and reliable drone probably the most important driver of the drone industry. Drones often generate large amounts of data – sometimes more than we can handle. Unmanned aerial vehicles only add value to the user if there are ways to process data quickly and without putting additional efforts into this process. The faster, the more accurate, and the easier the images can be evaluated, the better. Combining drones and artificial intelligence seems to be the answer to the above-mentioned challenges. Nowadays, almost every company that deals with data processing, analytics or ‘autonomous’ flight control and claims the use of artificial intelligence, machine or deep learning.

To optimize differentiable parameters, techniques of Machine Learning can be applied. Unlike software that has been programmed manually and performed tasks with specific instructions (like Computer Vision software), Machine Learning algorithms are designed in such a way that they can learn and improve over time when exposed to new data.

The main contribution of this paper is as follows:

1. A novel listwise loss function based on ranking evaluation measures is proposed for person re-identification. An online ranking within training batches is performed to evaluate the importance of different triplets of probe, misranked true and false correspondences and to weight the loss with the rank improvement for a given query.
2. As mentioned, , the goal of drones and artificial intelligence is to make efficient use of large data sets (such as aerial images) as automated and seamless as possible. No one wants to look at 5000 plain white picture of a wind turbine and look for tiny cracks. Drones can only unlock their full potential when data acquisition and data analytics happen at a high (or someday full) degree of automation. Great potential to process this mass of data as automated as possible seems to be ML or DL approaches.

VI. CONCLUSION

Existing deep learning methods are solely based on the minimization of a loss defined on a certain similarity metric between different examples. However, the final evaluation measures are computed on the overall ranking accuracy. Inspired by the learning-to-rank method LambdaRank, the optimisation approach directly incorporates these evaluation measures in the loss function. During training, each image in the training batch is used as probe image in turn and the rest as gallery. For each query, the mean average precision and rank 1 score are calculated. Then triplets are formed by the probe image and a pair of mis-ranked true and false correspondences. The loss of one triplet is weighted by the improvement of these evaluation measures by swapping the rank positions of the true and false correspondences.

A novel listwise loss function based on list ranking for person re-identification is proposed. This loss considers the re-identification ranking problem in a conceptually more natural way than previous work by directly taking into account the ranking evaluation scores. Experimentally it is shown that this loss outperforms other common loss functions and achieves state-of-the- art results.

Thus, employing various forms of hybrid BCI in brain-controlled and ML based UAVs demands further investigation. The potential of the hybrid BCI approach to overcome the limitations of psychophysiology measures in combination with smart control strategies, including implicit control, shows a clear path to significantly improve human–machine interaction in UAV scenarios.

This article reviewed the benefits of artificial intelligence aided mechanisms for person re-identification and BCI. We introduced the major families of machine learning algorithms and discussed their applications in the context of important tasks such as re-identifying people across various cameras, BCI etc. The classes of supervised, unsupervised, and reinforcement learning tools were investigated, along with the corresponding modelling methodology and possible future applications. In a nutshell, machine learning is an intelligence aided networking research.

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