Title: Evolutionary Learning and Optimisation

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Abstract: Learning and evolution are two fundamental forms of adaptation in Nature. They are also indispensable in artificial intelligence systems. This series of talks describe some research work in learning and optimisation that is not well covered in the literature.

Firstly, we will present some of the work in multi-objective evolutionary learning and its applications. Most, if not all, machine learning problems are defined by a single loss function. Yet the vast majority of those loss functions have two or more terms summed together through hyper-parameters. A closer examination of those loss functions reveals that there are in essence two or more conflicting objectives that a loss function tries to minimise, e.g., accuracy and regularisation. This talk formulates machine learning as a multi-objective problem, instead of trying to combine different objectives into a single loss function through a weighted sum. While the weighted sum approach is simpler, it does require additional time and effort to tune hyper-parameters (weights). This talk starts with ensemble learning. Then it describes a simple idea of multi-objective learning and its natural fit to ensembles. Existing multi-objective evolutionary algorithms can be used as multi-objective learning algorithms without requiring the objective functions to be differentiable or even continuous. Selected examples of multi-objective learning in class imbalance learning, software effort estimation and fair machine learning will be presented to illustrate the flexibility and generality of multi-objective learning. It is argued that multi-objective learning can be an effective approach towards achieving different trade-off in various practical learning scenarios.

Secondly, we will take a closer look at multi-objective evolutionary algorithms, which could be used as learning algorithms above. In particular, we will discuss strategies and techniques for dealing with a large number of objectives, including (a) approaches to reduce the the number of objectives so that a many objective optimisation problem could be simplified; (b) methods for approximating or re-defining the dominance relationship between multi-objective solutions without changing the optimisation goal of original problems; and (c) techniques for managing convergence and diversity archives separately so that the newly proposed algorithm could find a better and more diverse set of nondominated solutions.

Thirdly, we will conisder a challenging class of practical problems — class imbalance classification, which occur frequently in applications such as fault diagnosis and fraud detection, etc. In particular, we will discuss ensemble approaches to class imbalance classification, including both off-line and online scenarios and multiple classes. It is argued that ensemble approaches can be very effective in handling complex learning problems. Finally, we try to go beyond classical frameworks of learning and optimisation. The basic concepts of self-aware and self-expressive systems are first introduced. Then a reference architecture of self-aware and self-expressive systems is presented. A simple case study using smart camera networks will be given to illustrate how self-awareness and self-expression could facilitate the development of a solution to the handover problem in smart camera networks.