Foundations of Artificial Intelligence and Applications

Sami Mian

Department of Electrical and Computer Engineering, University of Pittsburgh, Pittsburgh, PA, USA

I. INTRODUCTION

The latest generation of artificial intelligence (AI) is based on today's cutting-edge technologies, including big data processing, cloud computing, machine learning, robotics, service-oriented computing, quantum computing, and Internet of Things (IoT). On one side, AI is supported and improved by these cutting-edge technologies. On the other side, AI is applied in many domains to augment the performance and capacities of many applications. Both the usefulness of AI in these domains and the inherent improvements that have been made in the pursuit of these large-scale technologies has caused an exponential increase in modern AI capabilities.

In the following sections, we will present an overview of the papers in this issue that support the development of AI and apply AI to extend and improve performance and capacities in several application domains. These papers include both academic research papers and industrial application papers.

II. FUNDAMENTALS SUPPORTING AI DEVELOPMENT

We selected two papers in this topic area that support the fundamental issues in the development and improvement of artificial intelligence research and education.

The first paper deals with a number of problems in the non-Euclidean data and its characterization. The first problem arises in studying and defining the distinction among Euclidean and non-Euclidean geometry. The second problem arises while dealing with the non-Euclidean geometry in true, false, and uncertain regions. The third problem arises while investigating some patterns in non-Euclidean datasets. This paper addresses these issues with real-life examples in big data processing, data visualization, knowledge representation, and quantum computing, which are important issues to address in artificial intelligence studies [1].

Quantum computing is a rapidly growing field that has received a significant amount of support in the past decade in industry and in research community. Several physical quantum computers are now freely available to use through cloud services, with some implementations supporting upwards of hundreds of qubits. These advances mark the beginning of the noisy intermediate-scale quantum (NISQ) era of quantum computing, paving the way for hybrid quantum-classical (HQC) systems. The second paper in this issue provides an introductory overview of gate-model quantum computing through the Visual IoT/Robotics Programming Language Environment and a survey of recent studies of NISQ era quantum computers to HQC machine learning. The main purpose of the paper is to promote artificial intelligence and quantum computing application and education [2].

III. DEPLOYMENT OF AI IN APPLICATION DOMAINS

We selected three papers in this topic area that applies artificial intelligence concepts and techniques to implement and improve the other research and industry domains.

The first paper in this area applies ant colony optimization technique of artificial intelligence in the security study of Wireless Sensor Networks(WSNs).

WSNs have become more and more widely used due to the rapid growth of the Internet technologies, such as IoT, Artificial Intelligence of Things, and Robot as a Service in cloud computing. As open and public wireless transmission media are easy to be attacked, security is one of the primary design concerns for WSNs. Current solutions consider routing and data encryption as two isolated issues, providing two partial security solutions. In this paper, the WSNs communication process is partitioned into a data path selection phase and a data encryption phase. An improved transmission method based on ant colony optimization and threshold proxy re-encryption for WSNs are proposed. The method resists internal and external attacks and ensures safe and efficient data transmission. In the data path selection stage, the ant colony optimization algorithm is used for network routing. The improvement of the pheromone concentration is proposed. In order to resist attacks from external attackers, proxy re-encryption is extended to WSNs in the data encryption stage. The threshold secret sharing algorithm is introduced to generate a set of re-encryption key fragments composed of random numbers at the source node. The performance of the model is confirmed via simulation studies [3].

Unmanned aerial vehicles have been widely used in different domains, including military, industrial, business, and education. It has been a domain where artificial intelligence shows significant impact.

The second paper in this section applies machine learning to achieve intelligent decision-making of unmanned aerial vehicle (UAV) based on the situation information in air combat. A new maneuvering decision method based on deep reinforcement learning is proposed to achieve the goal. The autonomous maneuvering model of UAV is established through a Markov Decision Process. The Twin Delayed Deep Deterministic Policy Gradient algorithm and the Deep Deterministic Policy Gradient algorithm in deep reinforcement learning are used to train the model. The experimental results of the two algorithms are analyzed and evaluated. The simulation results show that the proposed algorithm has

---

Corresponding author: Sami Mian (e-mail: stmian@asu.edu)

stronger decision-making performance and faster convergence speed and is more suitable for solving given problems in this study [4].

Welded studs and their quality are important issues in manufacture. For example, there are hundreds of welded studs in a car. The posture of a welded stud determines the quality of the body assembly, thus affecting the safety of cars. It is crucial to detect any problem in the posture of the welded studs. The third paper in this section applies machine learning for detecting the weld stud's pose based on photometric stereo and neural network. As a part of the study, a machine vision-based stud dataset collection system is built to achieve the stud dataset labeling automatically. Then, a photometric stereo algorithm is applied to estimate the stud normal map, which is fed as the input is to neural network. An improved lightweight YOLOv4 neural network is applied to detect stud position to address the shortcomings of traditional testing methods. The analytic and experimental results show that the stud pose detection system proposed in the paper

achieves rapid detection and high accuracy positioning of the stud [5].

REFERENCES

[1] P. K. Singh, "Data with non-Euclidean geometry and its characterization," DOI: 10.37965/jait.2021.12001.

[2] G. De Luca, "A survey of NISQ era hybrid quantum-classical machine learning research," DOI: 10.37965/jait.2021.12002.

[3] J. Liu, Z. Liu, C. Sun, and J. Zhuang, "A data transmission approach based on ant colony optimization and threshold proxyre-encryption in WSNs," DOI: 10.37965/jait.2021.12004.

[4] S. Bai, S. Song, S. Liang, J. Wang, B. Li, and E. Neretin, "UAV maneuvering decision-making algorithm based on twin delayed deep deterministic policy gradient algorithm," DOI: 10.37965/jait.2021.12003.

[5] X. Zhang and G. Wang, "Stud pose detection based on photometric stereo and lightweight YOLOv4," DOI: 10.37965/jait.2021.12005.