

Chapter 2

Quantum-Inspired Automatic Clustering Technique Using Ant Colony Optimization Algorithm

Sandip Dey

OmDayal Group of Institutions, India

Siddhartha Bhattacharyya

RCC Institute of Information Technology, India

Ujjwal Maulik

Jadavpur University, India

ABSTRACT

Quantum computing has emerged as the most challenging field of research in efficient computation. This chapter introduces a novel quantum-inspired ant colony optimization technique for automatic clustering. This chapter presents an application of this proposed technique to the automatic clustering of real-life gray-scale image data sets. In contrary to the other techniques, the proposed one requires no previous knowledge of the data to be classified. It finds the optimal number of clusters of the data by itself. The Xie-Beni cluster validity measure has been employed as the objective function for clustering purpose. Effectiveness of the proposed technique is exhibited on four real-life gray-scale images. Superiority of the proposed technique is established over its counterpart with respect to various aspects, which include accuracy, stability, computational time and standard errors. Finally, a statistical supremacy test, called unpaired two-tailed t-test, is conducted between them. It shows that superiority in favor of the proposed technique is established.

DOI: 10.4018/978-1-5225-5219-2.ch002

1. INTRODUCTION

Clustering is defined as segregating an unlabeled data set into groups of similar objects. Each group is known as “cluster”. The objects in one cluster are similar between themselves, whereas these objects possess dissimilarity to the objects of any other groups. Formally, clustering can be defined as follows:

$$S = \bigcup_{k=1}^m C_k \quad (1)$$

where, $C \subset S$, $C = \{C_1, C_2, \dots, C_m\}$ and $C_k \cap C_j = \phi$ for $k \neq j$. Subsequently, any object exactly lies in only one C_k where, $k \in \{1, 2, \dots, m\}$. From the last few decades, cluster analysis has been used in various fields successfully. These fields include engineering (e.g., electrical and mechanical engineering, machine learning, pattern recognition, artificial intelligence and so on), social sciences (e.g., psychology, sociology, and education), computer sciences (e.g., image segmentation, web mining, textual document collection), medical sciences (e.g., psychiatry, biology, microbiology and pathology), earth sciences (e.g., geology, geography, and remote sensing) and economics (e.g., marketing and business). In the literature, a number of different clustering algorithms have been introduced for various applications (Jain, 1999; Bakhshi, 2012).

The concept of Quantum Computing (QC) has been emerged by exploiting the principles of quantum mechanical phenomena. To research in this area is probably the most demanding and challenging task of twenty-first century. The behavior of QC can be described by the Schrödinger equation (Han, 2002). Quantum bits (qubits) are the smallest unit in QC. Superposition of states is a very important feature of QC where two states are combined in the fashion of linear superposition satisfying some probabilistic criteria. Unlike classical computer, the state space becomes n -dimensional for an n -qubits QC. Hence, this exponential growth of the state space makes QC perform exponentially faster compared to its classical computer (conventional computer). Like this computer, QC also possesses different quantum logic gates, called Q-gate which operates on a small number of quantum bits. Some popular examples of these quantum logic gates are CNOT, Hadamard gate and rotation gate (Hey, 1999) to name a few.

Quantum computer is much faster than its counterpart in terms of computational capability (Han, 2002). Richard Feynman discovered that the limitation of the computational capability of conventional computers can be overcome successfully with the use of quantum effect (Talbi, 2004). QC can possess its inherent parallelism capability, which in turn makes algorithms to execute exponentially faster compared

26 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/quantum-inspired-automatic-clustering-technique-using-ant-colony-optimization-algorithm/202544

Related Content

A Survey: Threats and Vulnerabilities in Cloud

Srishti Sharma and Yogita Gigras (2018). *Cyber Security and Threats: Concepts, Methodologies, Tools, and Applications* (pp. 181-191).

www.irma-international.org/chapter/a-survey/203504

Viewpoint-Based Modeling: A Stakeholder-Centered Approach for Model-Driven Engineering

Klaus Fischer, Julian Krumeich, Dima Panfilenko, Marc Bornand Philippe Desfray (2018). *Computer Systems and Software Engineering: Concepts, Methodologies, Tools, and Applications* (pp. 679-704).

www.irma-international.org/chapter/viewpoint-based-modeling/192898

Review of Applications of Energy Harvesting for Autonomous Wireless Sensor Nodes

Wilma Pavitra Puthran, Sahana Prasad and Rathishchandra Ramachandra Gatti (2023). *Energy Systems Design for Low-Power Computing* (pp. 143-165).

www.irma-international.org/chapter/review-of-applications-of-energy-harvesting-for-autonomous-wireless-sensor-nodes/319994

Wavelet Energy-Based Adaptive Retinex Algorithm for Low Light Mobile Video Enhancement

Vishalakshi G. R., Gopala Krishna and Hanumantha Raju (2023). *Novel Research and Development Approaches in Heterogeneous Systems and Algorithms* (pp. 16-39).

www.irma-international.org/chapter/wavelet-energy-based-adaptive-retinex-algorithm-for-low-light-mobile-video-enhancement/320122

The Influence of Human Resources Management Processes (HRMPs) to Achieving Sustainable Competitive Advantage

Mufleh Amin AL Jarrah, Louay Karadsheh, Muawya Naser and Samer Alhawari (2020). *Disruptive Technology: Concepts, Methodologies, Tools, and Applications* (pp. 1484-1502).

www.irma-international.org/chapter/the-influence-of-human-resources-management-processes-hrmps-to-achieving-sustainable-competitive-advantage/231252