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目　　次

光电测量信息大气折射误差修正的数学模型研究

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摘 要：为降低光电测量信息的大气折射误差，提升光电测量信息精度，研究一种光电测量信息大气折射误差修正数学模型，通过分析大气环境特征与湿度、压强及温度等参数，运算光在大气中的折射率及大气折射率的高度分布情况，创建俯仰角大气折射误差修正数学模型，并利用高斯积分运算俯仰角折射修正值，实现对光电测量信息俯仰角大气折射误差的修正。以某飞机校靶场校飞试验中的光电测量信息为实验数据，检验该模型的修正效果，实验结果表明，该模型修正后可更大程度地降低或消除光电测量信息的剩余误差，具有较高的距离误差与仰角误差修正效果，提升光电测量信息的精确度，满足数据处理的高精度需求。

关键词：光电测量；大气折射；误差修正；数学模型；折射率；高斯积分
中图分类号：TN247 **文献标识码**：A **doi**：10.14016/j.cnki.jgzz.2021.08.073

Study on mathematical model of atmospheric refraction error correction of photoelectric measurement information

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Abstract: A mathematical model of atmospheric refraction error correction of photoelectric measurement information is studied to reduce atmospheric refraction error of photoelectric measurement information and improve the accuracy of photoelectric measurement information. Through analyzing the characteristic of atmospheric environment and parameters such as temperature and humidity, pressure, and operation index of refraction of light in the atmosphere and the height of the atmospheric refractive index distribution, create pitching Angle of atmospheric refraction error correction model, and by using gauss integral operation pitching Angle refraction revised, realize the pitching Angle of photoelectric measurement information of atmospheric refraction error correction. In a school shooting range school flew photoelectric measurement information for the experimental data of test, test the modification effect of the model, the experimental results show that the model is adjusted to a greater degree to reduce or eliminate the photoelectric measuring the residual error of information, has the high distance error and Angle error correction effect, improve the photoelectric measuring the accuracy of the information, meet the demand of high accuracy of the data processing.

Key words: photoelectric measurement; atmospheric refraction; error correction; mathematical model; the refractive index. gauss integral

1 引言

光学测量设备作为靶场测量关键设备之一，是以光学原理作为依据，以测量与记录试验目标的飞行轨迹作为关键任务，获取大地坐标内飞行目标的时间与位置的关系，进而获取到目标飞行的弹着点、加速度以及速度等关键参数[1]。它的特点为性能稳定可靠性强、直观性强、测量精度高等，然而当光波在大气层的传播过程中，随着气压、温度、湿度与高度的持续改变，光波的路径方向与速率也逐渐发生改变。光学测量系统在光波折射效应的影响作用下，其测量所得的空中目标信息属于一种视在位置信息，而不属于真实位置信息，也就是大气折射导致的误差包含于测量信息内的距离、俯仰角与方位角之内[2-3]。通常情况下，对飞行目标实施光学测量时均在距离较远的条件下完成，所获得的测量信息结果的精确度受大气折射率变化的影响[4]。当光线经由大气层进行传播时，易产生折射，对于测角和测距系统误差而言，此类大气折

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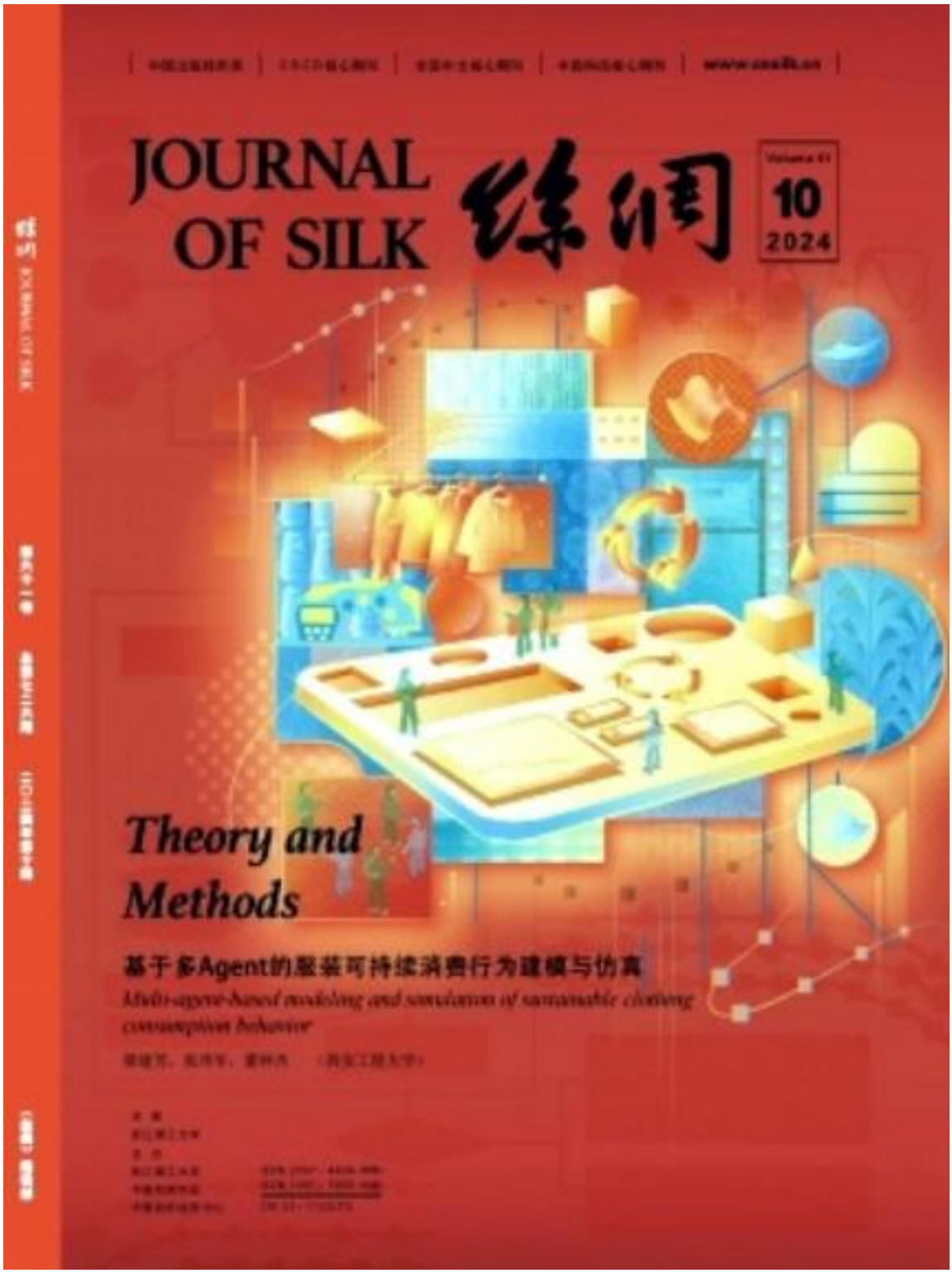
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Theory and Methods
基于多Agent的服装可持续消费行为建模与仿真
Multi-agent-based modeling and simulation of sustainable clothing consumption behavior

目录

基于 GRA-GA-BP 神经网络的家居服面料透气性能预测

Prediction of breathability performance of household apparel based on GRA-GA-BP neural network

王彬霞[1,2,3,4]，王春红[1,3,4]，陈雅娴[1,4]，周金香[2]，殷兰君[2]，杨道鹏[3]

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摘要：本文构建了一种改进 BP 神经网络模型来预测家居服面料的透气性能，能为家居服设计提供重要的参考。首先，采用灰色关联分析法(Grey Relation Analysis，GRA)，选择与透气率关联度较大的因素作为研究对象。其次，采用遗传算法(GA)优化 BP 神经网络的结构参数，构建基于灰色关联分析的遗传算法优化 BP(GRA-GA-BP)神经网络预测模型。选取 58 种面料成分不同、织物组织各异的家居服面料，其中 42 种为模型训练样本，16 种为测试样本对建立的模型进行验证。实验结果表明，透气率实测值与预测值平均相对误差为 8.39%；对透气率实测值与预测值进行相关性分析，拟合优度 R^2 为 0.976。研究表明，该预测模型预测效果良好、预测精度高，在一定程度上可以精准预测家居服面料的透气率。

关键词：织物；家居服；灰色关联分析；改进 BP 神经网络；透气性预测

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随着人们生活水平的提高，人们对于家居服的舒适性有了更广泛的关注和更高的要求，而影响家居服面料舒适性的关键因素之一是织物的透气性[1]。当面料的两侧有压力差异时，它们的通风特性就被称为透气性[2-3]。影响面料透气率的因素有纤维间的空隙、纱线直径、织物密度、厚度、平方米质量、织物组织结构及面料组成成分等[4-5]。目前国内外对于家居服研究的论文较少，家居服的舒适性研究还比较欠缺，对于透气性的研究则更为重要。邵景峰等[6]构建了一种基于支持向量机的精纺毛织物透气性预测模型，与现有 BP 神经网络预测模型相比，其预测精度提高了 3%；Zhu 等[7]建立了几种预测透气性的分析模型，发现 Hagen-Poiseuille 方程比其他模型具有更好的预测性；徐瑞东等[8]拟合织物透气率与纱线线密度、织物经纬纱密度、孔径 dp 之间的函数关系建立拟合函数来预测全棉织物的透气性，所计算的实测值与预测值相关系数高。本文的研究对象属于高度非线性问题，因此对于家居服面料透气性能的预测更适合用神经网络来完成。然而，经典的 BP 神经网络(Back-Propagation，BP)的训练与预测性能较差，并且容易出现陷入局部最优解的情况，其他神经网络不适用于本文[9]。遗传算法(Genetic Algorithm，GA)是一种模拟自然进化过程以寻找最优解的方法，适用于解决复杂的组合优化问题，因为它能迅速提供较好的优化结果[10-11]。利用遗传算法改进 BP 神经网络不仅能有效避免 BP 神经网络在选择过程中的随机性缺陷，还能显著加快其收敛速度，进而提升模型的预测精度和稳定性[12-13]。

综上所述，本文选取了涵盖不同面料成分、不同织物组织的共 58 种家居服面料，首先采用灰色关联分析，选取对家居服面料透气率较大的影响因素作为研究对象，即作为预测模型的输入层，然后构建基于灰色关联分析的遗传算法优化 BP(GA-BP)神经网络预测模型，最后对构建的模型进行验证。该模型可以完成对市场上不同类型家居服面料透气性能的预测，在一定程度上节约了测试成本和时间，同时可为家居服的设计提供参考。

1　家居服面料透气率影响因素的灰色关联分析

织物透气性与织物的经纬纱密度、经纬纱表观直径、织物厚度、单位体积质量纤维性质、纱线结构和织物组织结构等因素有关[14]。但各影响因素对家居服面料透气率并未产生规律性的线性影响，因此，可以将其看作灰色系统，而灰色关联

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Several relaxed CQ-algorithms for the split feasibility problem with multiple output sets

Original Research Published: 10 March 2025

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Aims and scope

Submit manuscript

Yu Cao, Yishuo Peng, Yasong Chen & Luoyi Shi

Abstract

In this paper, we present a pair of CQ-algorithms solving the split feasibility problem with multiple output sets and prove their strong convergence. Various methods are used in the algorithm to improve usability and increase the iteration speed. To broaden the algorithm's usability, we incorporate an adaptive stepsize and the algorithm works based on replacing the projection to the half-space with that to the intersection of two half-spaces. To hasten the convergence process, the"dividing by norm" approach is selected and the subsequent output hinges on the prior step's outcome. Finally, our numerical

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ORIGINAL RESEARCH

Several relaxed CQ-algorithms for the split feasibility problem with multiple output sets

Yu Cao[1] · Yishuo Peng[1] · Yasong Chen[1] · Luoyi Shi[1]

Received: 13 September 2024 / Revised: 18 December 2024 / Accepted: 31 January 2025

Abstract

In this paper, we present a pair of CQ-algorithms solving the split feasibility problem with multiple output sets and prove their strong convergence. Various methods are used in the algorithm to improve usability and increase the iteration speed. To broaden the algorithm's usability, we incorporate an adaptive stepsize and the algorithm works based on replacing the projection to the half-space with that to the intersection of two half-spaces. To hasten the convergence process, the"dividing by norm" approach is selected and the subsequent output hinges on the prior step's outcome. Finally, our numerical tests in signal recovery demonstrate the superior efficacy of our algorithms.

Keywords Split feasibility problem with multiple output sets · Adaptive stepsize · Dividing by norm · Strong convergence · Signal recovery

Mathematics Subject Classification 65K15 · 90C30

1 Introduction

The split feasibility problem (SFP) can be formulated as finding an element h^* such that:

$$h^* \in C, \ and \ Ah^* \in Q, \tag{1}$$

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A novel study of kernel graph regularized semi-non-negative matrix factorization with orthogonal subspace for clustering

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ARTICLE INFO

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Kernel semi-non-negative matrix factorization
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Auxiliary variable

ABSTRACT

As a nonlinear extension of Non-negative Matrix Factorization (NMF), Kernel Non-negative Matrix Factorization (KNMF) has demonstrated greater effectiveness in revealing latent features from raw data. Building on this, this paper introduces kernel theory and effectively combines the advantages of semi-nonnegative constraints, graph regularization, and orthogonal subspace constraints to propose a novel model-Kernel Graph Regularized Semi-Negative Matrix Factorization with Orthogonal Subspaces and Auxiliary Variables (semi-KGNMFOSV). This model introduces auxiliary variables and reformulates the optimization problem, successfully overcoming the convergence proof challenges typically associated with orthogonal subspace-constrained methods. Furthermore, the model utilizes kernel methods to effectively capture complex nonlinear structures in the data. The semi-nonnegative constraint, along with orthogonal subspace constraints incorporating auxiliary variables, enhances optimization efficiency, while graph regularization preserves the local geometric structure of the data. We develop an efficient optimization algorithm to solve the proposed model and conduct extensive experiments on multiple real-world datasets. Additionally, we investigate the impact of three different initialization strategies on the performance of the proposed algorithm. Experimental results demonstrate that, compared to classical and state-of-the-art methods, the proposed model exhibits superior performance across all three initialization strategies.

1. Introduction

With the rapid development of modern technology, data is often presented in higher dimensional forms. Directly analyzing and processing these high-dimensional data not only reduces work efficiency, but may also be affected by redundant information in the results. Therefore, how to effectively retrieve, classify, and extract valuable information has become one of the main research issues. Clustering algorithm, as an effective tool for data information processing, plays an important role in various disciplines. It is widely used to mine the intrinsic features of data structures, extract main information, and reduce data dimensions. As an unsupervised learning method, data clustering is used to reveal the structure and patterns in high-dimensional data, identify similarities between patterns, reduce data complexity and facilitate interpretation, thus achieving the goal of placing highly similar data into one category. Therefore, the key to clustering tasks is to discover the intrinsic structural information of the original data, thereby enhancing its discriminative ability.

Due to its potential for clustering representation, Non-negative Matrix Factorization (NMF) [17] has garnered widespread attention in the academic community as an effective method for data dimensionality reduction and feature extraction, and has been widely applied to clustering tasks [11]. Generally, NMF imposes non-negativity constraints on both the basis matrix and the coefficient matrix, endowing it with the capability to generate more representative and interpretable non-negative low-rank matrices. In fact, owing to its characteristic of partial feature representation, NMF has been successfully extended to various domains, including image analysis [32], spectral analysis [27], and blind source separation [42].

In recent years, researchers have proposed various variants of NMF to extend the applicability of the standard NMF optimization problem. However, in practical scenarios, many datasets are not entirely non-negative, thereby limiting the applicability of NMF and sometimes hindering its ability to interpret the datasets effectively. To enhance the applicability of NMF to data matrices, Ding et al. [7] introduced semi-Non-negative Matrix Factorization (semi-NMF), which relaxes the constraints of the factorization. Semi-NMF enables NMF not only to analyze non-negative data

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A novel study of kernel graph regularized semi-non-negative matrix factorization with orthogonal subspace for clustering

Yasong Chen [1] ✉, Wen Li ✉, Junjian Zhao [1] ✉

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Abstract

As a nonlinear extension of Non-negative Matrix Factorization (NMF), Kernel Non-negative Matrix Factorization (KNMF) has demonstrated greater effectiveness in revealing latent features from raw data. Building on this, this paper introduces kernel theory and effectively combines the advantages of semi-nonnegative constraints, graph regularization, and orthogonal subspace constraints to propose a novel model-Kernel Graph Regularized Semi-Negative Matrix Factorization with Orthogonal Subspaces and Auxiliary Variables (semi-KGNMFOSV). This model introduces auxiliary variables and reformulates the optimization problem, successfully overcoming the convergence proof challenges typically associated with orthogonal subspace-constrained methods. Furthermore, the model utilizes kernel methods to effectively capture complex nonlinear structures in the data. The semi-nonnegative constraint, along with orthogonal subspace constraints incorporating auxiliary variables, enhances optimization efficiency, while graph regularization preserves the local geometric structure of the data. We develop an efficient optimization algorithm to solve the proposed model and conduct extensive experiments on multiple real-world datasets. Additionally, we investigate the impact of three different initialization strategies on the performance of the proposed algorithm. Experimental results demonstrate that, compared to classical and state-of-the-art methods, the proposed model exhibits superior performance across all three initialization strategies.

Introduction

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Results in Mathematics

Approximation Estimation of Interpolation Projection Operators in Shift-Invariant Subspaces Based on Mixed-Norm

Yasong Chen and Junjian Zhao

Abstract. Mixed-norm is a popular tool in recent years and has received the attention of many mathematicians. In this paper, based on the study of signals in the $L_{\vec{p}}$ (mixed-norm) sense, we provide a study on the approximation of signals by interpolation projection operator I in the mixed-norm $L_{\vec{p}}$ sense. That is to say, specific conclusions on the approximation order of the interpolation projection operator I based on mixed-norm are given. In fact, the non commutativity of integrals in the sense of mixed-norm poses some difficulties in estimating the error bound of approximation, and this is one of the core issues that this paper must address.

Mathematics Subject Classification. Primary 41A35, 41A15, 41A58, 42B35, 42C40.

Keywords. Mixed-norm, Interpolation projection operators, Approximation order, Shift-invariant subspaces.

1. Introduction and Preliminaries

A major class of problems dealt with by approximation theory is the convergence of various projection operators (see [13,14,23]), many of which use analysis methods in the $L_p(\mathbb{R}^d)$ sense ([31–33]). For example, the study of the sampling theory of shift-invariant subspaces in the sense of $L_p(\mathbb{R}^d)$ can be seen as the study of (sampling based) projection operators defined on these subspaces ([1–3]). Therefore, studying the approximation of these projection operators is of great significance for sampling theory, or it can be seen that the approximation problem at this time is proposed from the perspective of

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Approximation Estimation of Interpolation Projection Operators in Shift-Invariant Subspaces Based on Mixed-Norm

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Abstract

Mixed-norm is a popular tool in recent years and has received the attention of many mathematicians. In this paper, based on the study of signals in the $L_{\vec{p}}$ (mixed-norm) sense, we provide a study on the approximation of signals by interpolation projection operator I in the mixed-norm $L_{\vec{p}}$ sense. That is to say, specific conclusions on the approximation order of the interpolation projection operator I based on mixed-norm are given. In fact, the non commutativity of integrals in the sense of mixed-norm poses some difficulties in estimating the error bound of approximation, and this is one of the core issues that this paper must address.

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Orthogonal graph regularized non-negative matrix factorization under sparse constraints for clustering

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ARTICLE INFO

MSC:
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Keywords:
NMF
Manifold
Orthogonality
Sparse constraints
Clustering

ABSTRACT

The standard NMF algorithm is not suitable for sampling data from low-dimensional manifolds embedded in high-dimensional environmental spaces, as the geometric information hidden in feature manifolds and sample manifolds is rarely learned. In order to obtain better clustering performance based on NMF, manifold and orthogonal constraint, a new type of model named Orthogonal Graph regularized Non-negative Matrix Factorization model under Sparse Constraints (OGNMFSC) is proposed. Firstly, this type of model constructs a nearest neighbor graph to encode the geometric information of the data space, in order to obtain more discriminative ability by preserving the structure of the graph. Secondly, this type of model adds orthogonal constraints to achieve better local representation and significantly reduce the inconsistency between the original matrix and the basis vectors. Thirdly, by adding sparse constraints to obtain a sparser representation matrix, the clustering performance of the model can be improved. The main conclusion of this paper is that two effective algorithms have been generated to solve the model, which not only provides theoretical convergence proof for these two algorithms, but also demonstrates significant clustering performance in experiments compared to classical models such as K-means, PCA, NMF, Semi-NMF, NMFSC, ONMF, GNMF, NeNMF.

1. Introduction

The purpose of clustering is to group data points with high similarity into one category, while dividing data points with low similarity into different categories. During this process, it is well known that one of the most important tasks is to find an effective representation of the original data. In order to represent or mine the inherent structural information in the original data, many researchers have done a lot of work. For example, the work of factorizing a data matrix. The most classic methods of matrix factorization include Singular Value Decomposition (Kalman, 1996) (SVD), Principal Component Analysis (Pudil, Somol, & Haindl, 1990) (PCA), and Non-negative Matrix Factorization (Lee & Seung, 1999) (NMF), among others. In fact, one of the main purposes of these factorization (decomposition) methods is to reduce the dimensionality of the original data and simultaneously extract the hidden features required for data analysis. Due to the many comprehensive advantages of NMF (Francisco, Monica, Pedro, Alberto, et al., 2006; Lee & Seung, 1999; Li, Yang, Xu, Qin, & Zhang, 2014; Paatero & Tapper, 1994), this paper will study the clustering theory based on NMF.

In 1994, Paatero and Tapper (1994) first introduced the idea of NMF. In 1999, Lee and Seung (1999) published the well-known result on the study of non-negative matrices for mathematics in the journal Nature, proposing a new matrix factorization method–NMF. The publication of this paper quickly had significant impacts in the following areas. Firstly, a large amount of large-scale data in scientific research needs to be effectively processed in matrix form, and the idea of NMF provides a new method for processing large-scale data. Secondly, compared with some traditional algorithms, NMF algorithm has many advantages, such as simple algorithm implementation, concise factorization form, interpretability of factorized matrices, and less storage space, so it is very meaningful to study it. Thirdly, NMF models have also been widely applied in fields such as text mining (Li et al., 2014; Shahnaz, Berry, Pauca, & Plemmons, 2006), face recognition (Chen, Chen, Chen, & Pan, 2013; Xue, 2007), gene expression (Francisco et al., 2006; Gao & Church, 2005), and hyperspectral image solution mixing (Ang & Gillis, 2019; Pompili, Gillis, Absil, & Glineur, 2014) and so on. The application of these practical scenarios has in turn promoted the development of NMF and brought rich achievements and many meaningful research directions.

Sparsity is one of the important conditions of NMF for applications such as computation and storage. As is well known, the component based image representation obtained by traditional NMF is usually

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ORIGINAL ARTICLE

A novel robust zero-watermarking algorithm for medical images

Kun Hu[1] · Xiaochao Wang[2] · Jianping Hu[3] · Hongfei Wang[4] · Hong Qin[5]

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Abstract
A novel robust zero-watermarking algorithm for medical images is presented in this paper. The multi-scale decomposition of bi-dimensional empirical mode decomposition (BEMD) has exhibited many attractive properties that enable the proposed algorithm to robustly detect the tampering regions and protect the copyright of medical images simultaneously. Given a medical image, we first decompose a medical image adaptively into a finite number of intrinsic mode functions (IMFs) and a residue, by taking a full advantage of BEMD. The first IMF starts with the finest scale retaining fragile information and is best suitable for tampering detection, while the residue includes robust information at the coarser scale and is applied to the protection of intellectual property rights of medical images. Next, the feature matrices are extracted from the first IMF and the residue via singular value decomposition, which achieves robust performance subject to most attacks. For a given watermark image, it is encrypted by Arnold transform to enhance the security of the watermark. Then, the feature images are constructed by performing the exclusive-or operation between the encrypted watermark image and the extracted feature matrices. Finally, the feature images are securely stored in the copyright authentication database to be further used for copyright authentication and tampering detection. A large number of experimental results and comparisons with existing watermarking algorithms confirm that the newly proposed watermarking algorithm not only has strong ability on tampering detection, but also has better performance in combating various attacks, including cropping, Gaussian noise, median filtering, image enhancement attacks, etc. The newly developed algorithm also shows great promise in processing natural images.

Keywords Medical images · Zero-watermarking · Bi-dimensional empirical mode decomposition · Singular value decomposition · Tampering detection

1 Introduction and motivation

Digital medical images store patient's private information and play a vital role in disease diagnosis [6,10]. Hence, the protection of patients' private information is of utmost importance to medical information system, because medical images might be duplicated, disseminated, and tampered by unauthorized individuals. To best protect the proprietary rights of the patient's medical images from being abused, digital image watermarking has been widely studied [13,16,17,22,33,34].

Traditional watermarking algorithms provide the copyright protection by embedding watermarks into the host image, which may bring three main problems for medical images due to their special requirements. First, inserting information into the host image inevitably modifies the orig-

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ORIGINAL ARTICLE

Robust and blind image watermarking via circular embedding and bidimensional empirical mode decomposition

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Abstract

In this paper, a robust and blind image watermarking algorithm via circular embedding and bidimensional empirical mode decomposition (BEMD) is developed. First, the watermark image is scrambled by Arnold transform to increase the security of the algorithm. Second, the Hilbert curve is adopted to reduce the scrambled 2D watermark image to one-dimensional watermark signal. Third, the host image is decomposed by BEMD to obtain the multi-scale representation in the forms of intrinsic mode functions (IMFs) and a residue. Then, the extreme points of the IMFs are extracted as the embedding locations. Finally, the one-dimensional watermark signal is repeatedly and cyclically embedded in the extreme locations of the first IMF according to the texture masking characteristics of the human visual system, which greatly improves the ability of our algorithm against various attacks. The final watermarked image is reconstructed by combining the modified first IMF and the residual. The watermark can be successfully extracted without resorting to the original host image. Furthermore, image correction can be applied before image watermarking extraction if there are geometric attacks in watermarked image. A large number of experimental results and thorough evaluations confirm that our method can obtain higher imperceptibility and robustness under different types of attacks, and achieve better performance than the current state-of-the-art watermarking algorithms, especially in large-scale cropping attack, JPEG compression, Gaussian noise, sharpening, Gamma correction, scaling, histogram equalization, and rotation attacks.

Keywords Image watermarking · Circular embedding · BEMD · Arnold transform · Hilbert curve

1 Introduction and motivation

With the widespread popularity of image acquisition equipments and the rapid development of digital media communication technologies, magnanimous images could be easily acquired, duplicated, revised, and disseminated. Apart from these conveniences, the abuse of images, copyright infringement, malicious dissemination have arisen and attracted extensive attentions in the area of digital media and information technologies. To solve the aforementioned issue and protect the copyright of images, image watermarking has been widely studied as a very promising information security technology and plays an important role in protecting the copyright of digital images.

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