A METHOD FOR DETECTING ABNORMAL CHANGES IN THE TEMPERATURE FIELD OF GRAIN BULK BASED ON HSV FEATURES OF CLOUD MAPS

C. Hongwei, W. Wu, Z. Wu, F. Han

HIGHLIGHTS

- Abnormal grain temperature changes were detected by calculating the similarity of HSV features in cloud maps.
- The F-measures were higher for the improved method than for methods based on HSV and LBP feature similarity.
- The improved method can detect abnormal heating of grain due to mold activity or spoilage and the fluctuation in grain temperature caused by aeration.
- The temperature field of the grain bulk in adjacent time periods has high similarity during normal storage.

ABSTRACT. *Analyses of grain temperature data are time-consuming and labor-intensive, and thorough analyses are difficult to perform. This article proposes an improved method based on the hue, saturation, and value (HSV) color feature similarity of temperature field cloud maps to detect abnormal changes in grain temperature. Historical grain temperature data are preprocessed to generate temperature field cloud maps. The improved method based on HSV feature similarity is used to calculate the similarity of temperature field cloud maps for two successive days during normal storage, and a similarity threshold is set. Five types of grain bulk temperature anomalies are then simulated. Additionally, a comparative experiment is carried out that considers traditional methods based on HSV feature similarity and local binary pattern (LBP) feature similarity. The results show that the average recall rates of the F-measures of the improved method, the traditional method based on HSV feature similarity, and the method based on LBP feature similarity are 96.2%, 89.3%, and 95.4%, respectively, and the processing speeds are 340, 300, and 690 ms per group, respectively. Finally, an abnormal grain temperature experiment is carried out. The experimental results show that the improved method can detect sudden changes in the temperature field due to mold activity or spoilage and the fluctuations in grain temperature caused by aeration.*

Keywords. *Grain storage, HSV feature, LBP feature, Similarity, Temperature.*

In China, grain storage safety mainly includes quality safety and quantity safety (Zhang et al., 2014a). Quality safety means that the storage environment and storage duration do not reduce the quality of the grain, while quantity safety ensures that grain has not been illegally removed during storage (Zhang et al., 2014b). Therefore, monitoring of both grain quality and grain quantity is needed in China.

To ensure the quality of grain during long-term storage, the storage environment is regulated by monitoring the temperature and humidity (Gonzales et al., 2009) and CO_2 concentration (Neethirajan et al., 2010). The temperature, humidity, and moisture can also be predicted by some models (Lawrence et al., 2012; Abalone et al., 2011; Gastón et al., 2009) to ensure the suitability of the storage environment and grain quality. Detecting the temperature and humidity of the grain bulk is necessary to ensure the quality of the grain, and monitoring the grain bulk is necessary to ensure the quantity of the grain. There are several methods for detecting stored grain quantity. Video surveillance is used in most granaries in China, although these systems are vulnerable to the power supply, are limited by the file type, and provide insufficient security (Lin, 2008). Qing et al. (2010) used wave velocity chromatography and attenuation chromatography to invert the dielectric constant and estimate the density of a grain bulk, and they combined velocity and attenuation tomography to estimate the height of the grain bulk. Therefore, the quantity of grain could be estimated according to the density and volume. Technology based on three-dimensional laser scanning (Wang and Feng, 2016; Zhu et al., 2016) can also be used to detect the quantity of grain. However, adding these sensors to a granary creates the need for additional personnel to manage the equipment, which increases the management cost of the granary.

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基于粮温时空相关性的储粮数量监管方法研究

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摘要： 针对我国储备粮人工稽核费时、费工等问题，提出了基于粮温时空相关性的储粮数量监管方法。首先，分析粮堆测温平面的自相关性与互相关性，检测粮堆异常发生的日期与平面；然后，分析粮堆异常日期内异常平面上测温线的自相关性，检测发生异常的测温线；接着分析异常测温线上测温点的自相关性，检测并统计异常点的个数；最后，根据异常点个数判定异常种类，进而实现储粮数量监管。在 3 个储粮区(低温区、中温区、高温区)中分别选取粮仓粮温进行相关性分析，根据分析结果设定测温平面自相关系数阈值为 0.8，互相关系数变化率阈值区间为 $[-0.15\ d^{-1}, 0.15\ d^{-1}]$；测温线的自相关系数阈值为 0.8；测温点的自相关系数阈值为 0.8；同时分析结果显示，短周期内测温线与点的互相关性无法作为异常判定依据。进行了储量监管试验，试验结果表明，基于粮温时空相关性的储粮数量监管方法不仅能够实现储粮数量监管，同时能够检测出粮堆发热等异常变化。

关键词： 粮温；储粮；数量监管；时空相关性
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Reserves Monitoring Method for Grain Storage Based on Temporal and Spatial Correlation of Grain Temperature

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Abstract: The supervision and verification of grain bulks is an important segment during storage. Reliable reserves monitoring method for grain storage can effectively guarantee national grain quantity security. To solve the problems such as time consuming, labor cost and other problems in the manual audit of reserves, a monitoring method for grain storage quantity based on correlation analysis was proposed. Firstly, the autocorrelation and intercorrelation of the temperature measurement planes in the grain bulks were analyzed, so that the abnormal date and planes were detected. Secondly, the autocorrelation and the intercorrelation of temperature measurement lines in the abnormal date were analyzed, and the abnormal lines were detected in the abnormal date. Then the autocorrelation and intercorrelation of the temperature measurement points in the abnormal temperature line were analyzed. The number of abnormal points was counted, and the type of abnormal occurrence and the abnormal proportion were determined according to the number. At the same time, the granaries were selected in three storage grain areas: low temperature zone, medium temperature zone and high temperature zone for correlation analysis. According to the analysis results, the threshold of autocorrelation coefficient of temperature measurement plane was set to be 0.8, the threshold of change rate of intercorrelation coefficient was $[-0.15\ d^{-1}, 0.15\ d^{-1}]$; the threshold of autocorrelation coefficient of temperature measurement line was 0.8; and the autocorrelation coefficient of temperature measurement point was 0.8. Meanwhile, the analysis results showed that the correlation between temperature measurement lines and points in short period can not be used as an anomaly criterion. The supervision test of grain storage was carried out. The test results showed that the grain storage supervision method based on the correlation analysis can not only realize the reserves monitoring, but also detect the local heating and other anomalies of grain bulk. The purpose was to analyze the correlation coefficient of grain temperature data in the granaries of several different grain storage areas, monitor the quantity of grain and provide a theoretical basis for the analysis of grain data in different regions.

Key words: grain temperature; grain storage; reserves monitoring; temporal and spatial correlation

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基于粮温统计特征的粮仓库存状态检测方法

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摘 要：粮仓历史库存状态的准确检测可以为清仓查库工作提供线索，该文通过分析粮温统计特征，提出了一种基于历史粮温统计特征的粮仓库存状态（主要包括空仓、新粮、通风 3 种状态）检测方法。利用粮堆上下相邻层温差和粮温的新异众比例检测空仓态，利用相邻层温差和粮温标准差检测新粮态，利用层温变化率和粮温标准差变化率检测通风态。提出了一种类多变量决策树的粮仓库存状态检测方法；通过分析 11 个粮仓历史粮温的统计特征，确定了决策树节点特征参数的最优阈值。最后选择 7 个不同省份的粮仓，利用提出的检测方法进行库存状态检测试验，试验结果显示空仓态、新粮态、通风态的查准率分别为 78%、74%、91%，查全率分别为 82%、70%、88%。试验结果表明基于历史粮温统计特征的粮仓库存状态检测方法能够较好的实现对空仓态和通风态的检测，能够基本实现对新粮态的检测。

关键词：粮食；温度；统计特征；库存状态；空仓；新粮；通风
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0 引 言

在中国，粮食储藏周期长（一般为 2～4 a），这期间容易发生以差换好、违规倒仓等影响库存粮食数量的问题，也容易发生结露、霉变等影响质量的问题，因此需适时进行库存检查。粮仓库存检查是粮食监管部门通过人工或机器协助的方式，定时对历史储藏过程中粮仓库存数量、质量的变化情况进行检查。国家每隔 10 a 会进行全国性库存实物检查，各省每年也会进行库存检查。但目前库存检查多由人工完成，工作量比较大，发现历史储藏中数量或质量问题的难度较大，因此需研究历史库存粮食状态的检测方法，为库存检查工作提供线索。

库存检查中质量检查主要是判断储藏过程中粮堆是否发生结露、霉变等影响粮食质量的问题。目前，关于粮堆质量预测判断的研究较多，吴子丹团队通过研究粮堆的物理场、生物场等之间的耦合关系提出了粮堆多场耦合理论，开辟了运用粮堆温度场、湿度场云图分析粮食质量变化的新途径[1-4]。Roberta 等[5]研究了筒仓中玉米储存时的温度场模型。在前期研究基础上，吴子丹团队利用温湿度场、微气流场等多场耦合模型实现小麦粮堆结露、霉变位置的分析和预测[6-8]；程树峰等利用温湿度场研究了稻谷、玉米、大豆储藏早期的真菌生长规律[9-11]。上述基于粮堆温湿度场进行结露、霉变的研究提出了一些预测判断模型，已经可以在库存检查中应用。库存检查中数量检查主要包括查验检查时的库存数量，同时检查历史储藏过程中粮食数量发生的异常变化（与出入仓等指令不匹配）。现有粮仓库存数量检测的方法包括基于压力传感器检测[12-15]、电磁波检测技术[16]、基于三维激光扫描技术[17-19]等，上述方法多需在粮仓内加装传感器，会增加粮仓管理和检测成本。目前，中国大部分粮库都已经安装了检温系统，检温系统采集获得了大量的历史粮温数据，部分研究者利用粮温数据提出一些检测方法，如秦骁[20]提出了储备粮数字监管策略，主要为 AID 策略、3R 策略和 ABC 策略。崔宏伟等[21]通过分析粮温数据的时空分布规律，提出了利用测温系统内的点、线、面之间的相关性进行储粮监管的方法；同时提出通过分析温度场云图 RGB 颜色特征进行储藏数量异常时间的检测方法[22]。上述研究策略与方法可以在不增加管理成本的基础上实现检测，但仅能对粮仓异常时段进行检测，并未对粮仓库存状态进行分类和判断，检测结果仍需大量人工分析和归类。为此，朱浩天[23]将粮仓库存状态归类为数量异常状态与质量异常状态，并利用粮温数据的统计特征基本实现了不同异常状态的检测。但其只依据一个统计特征判断异常状态，检测结果的准确性和可靠性不足。

为充分利用粮仓历史检温数据，提高库存状态检测结果的准确性与可靠性，同时减轻查库人员的工作量，为查库工作提供有效线索，本文主要研究基于粮温数据

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基于温度场云图的储粮数量监控方法研究

崔宏伟，吴文福，吴子丹※，韩 峰，张 娜，王雨佳
（吉林大学生物与农业工程学院，长春 130022）

摘 要：为保障储备粮按照计划进出仓库，同时减少储粮监管与稽核的工作量，该文提出了基于温度场云图 RGB 颜色特征的储粮监管方法。调用历史粮温数据并进行预处理，生成粮堆各平面温度场云图，利用温度场云图的 RGB 颜色特征分布计算云图的相似度，据此设定异常判定阈值，计算相邻时间粮堆各平面云图的相似度，依据阈值进行异常检测，从而实现储粮监管。同时该文通过模拟 5 种粮堆异常情况，进行了模拟检测试验，并与基于温度场云图 LBP 纹理特征的检测算法进行对比，结果显示：基于温度场云图 RGB 颜色特征的算法平均查全率、平均查准率、运算速率均优于基于云图 LBP 纹理特征的算法，分别为 98.6%、97.3%、320 ms/次。进行了储粮监管检测试验，结果表明，该方法不仅能够应用于储粮数量的监管，也能够检测出粮堆局部发热。该研究结果为储粮数量监控方法的提出奠定基础。

关键词：粮食；储藏；温度传感器；温度场云图；RGB 颜色特征；相似度；LBP 纹理特征
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Cui Hongwei, Wu Wenfu, Wu Zidan, Han Feng, Zhang Na, Wang Yujia. Monitoring method of stored grain quantity based on temperature field cloud maps[J]. Transactions of the Chinese Society of Agricultural Engineering (Transactions of the CSAE), 2019, 35(4): 296 － 298. (in Chinese with English abstract) doi：10.11975/j.issn.1002-6819.2019.04.036 http://www.tcsae.org

0 引 言

中国粮仓储量大，储藏周期长，为保证储藏过程中的粮食安全，通过监测粮仓内的温湿度[1]、CO_2 浓度[2]等信息，并通风预测模型[3-6]、温湿度或含水率预测模型[7-10]等调控储粮环境，从而保障储粮安全，以上研究多集中在品质安全、生物安全等方面，但由于粮库储量较大，若个别粮库发生虚报贴息、以差换好等违规、违法现象，会造成较大的经济损失，因此也应进行必要的储粮数量监管，而且中国粮库分布广使得粮库储量监管与稽核的工作量大，因此可靠储粮监管方法研究也具有重要的价值。

目前粮食数量检测方法主要有称重计量法、主动测量法以及视频监控等[11]。称重计量方法在美国等发达国家的大型粮库以及中国少量的国家级大型储备库采用[12-13]，但该方法对设备要求较高、维护成本较高，而且系统检测结果易受人为干扰影响[14]。主动测量法原理为测距原理，主要技术包括激光扫描、红外扫描等[15]，但该方法设备成本较高，而且多应用于煤堆体积的测量[16]。视频监控系统能够实时监测粮食数量，但视频监控系统易受供电影响，且监管的视频采用文件方式管理，安全性不足[11]。目前该领域的主要技术有：基于压力传感器检测[17-18]、电磁波检测技术[19]、基于三维激光扫描技术[20-21]等，3 种技术的应用需在粮仓加装检测设备，容易增加检测成本，另一方面激光扫描设备价格较高，而电磁波检测易受粮食种类、温度等因素影响检测精度，上述技术大范围的推广应用仍需待技术进一步突破。

针对上述研究存在的问题，本文利用粮库基本配备粮情监控系统采集的粮温数据进行储粮监管方法研究。正常储藏过程中，粮仓各测温点每日温度变化较小，相邻时段测温平面（不一定相邻）各测温点温度相关性较高[22]，形成的温度场云图具有较高相似度，因此可以通过检测相邻 2 d 温度场云图相似度实现储粮监管。国内外学者通过研究图像颜色、纹理、形状等特征检测图像的相似度。Murala 等[23]采用灰度共生矩阵来描述图像的纹理特征，并在灰度共生矩阵的基础上进一步推导出二阶矩、惯性矩、惯性熵等参数，形成了基于灰度共生矩阵的纹理特征表达参数族。灰度共生矩阵法准确地描述了图像纹理的灰度级结构，因此检索效果比较理想。Huang 等[24]提出多特征融合的图像检索方法，通过提取 RGB 颜色空间的颜色矩与 HSV 颜色空间中的颜色直方图作为颜色特征，提取改进的 Zernike 矩作为形状特征，灰度共生矩作为纹理特征，以 3 特征融合计算图像相似度。Ghosh 等[25]提出了颜色一致向量的表达方法，该方法将相同颜色信息的像素按照连通关系进行区域合并，从而形成颜色区域和颜色离散点，再进行区域一致性比对来完成图像相似度检测。Yan 等[26]提出一种分层 HSV 特征与分层纹理特征提取的图像相似度，并通过仿真试验验证该算法对复杂背景的相似图像检索性能更优。虽然有关图像

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检　索　报　告

一、检索要求

1. 委 托 人：崔宏伟 Hongwei, C (Cui, Hongwei)

2. 委托单位：吉林大学

3. 检索目的：论文被收录、所在期刊的影响因子以及分区情况

二、检索范围

Science Citation Index Expanded (SCI-EXPANDED)	1975-present	网络版
JCR-(Journal of Citation Report)-IF(Impact Factor)	2019	网络版
中国科学院文献情报中心期刊分区表(基础版)	2020	网络版
Engineering Village （ Database: Compendex）	1969-present	网络版

三、检索结果

1.委托人提供的 **1** 篇论文被SCI-E收录，论文被收录、所在期刊的影响因子以及分区情况见附件一。

2. 委托人提供的 **3** 篇论文被 EI 收录，论文收录情况见附件二。

特此证明！

东北师范大学科技查新咨询中心

教育部科技查新工作站（L24）

（盖　章）

检索报告人：谢福秀

2021 年 3 月 2 日

附件一：论文被SCI-E收录及其所在期刊的影响因子和分区情况

第 1 条，共 1 条
标题: A METHOD FOR DETECTING ABNORMAL CHANGES IN THE TEMPERATURE FIELD OF GRAIN BULK BASED ON HSV FEATURES OF CLOUD MAPS
作者: Hongwei, C (Hongwei, C.); Wu, W (Wu, W.); Wu, Z (Wu, Z.); Han, F (Han, F.)
来源出版物: TRANSACTIONS OF THE ASABE 卷: 63 期: 5 页: 1181-1191 DOI: 10.13031/trans.13663 出版年: 2020
Web of Science 核心合集中的 "被引频次": 0
被引频次合计: 0
摘要: Analyses of grain temperature data are time-consuming and labor-intensive, and thorough analyses are difficult to perform. This article proposes an improved method based on the hue, saturation, and value (HSV) color feature similarity of temperature field cloud maps to detect abnormal changes in grain temperature. Historical grain temperature data are preprocessed to generate temperature field cloud maps. The improved method based on HSV feature similarity is used to calculate the similarity of temperature field cloud maps for two successive days during normal storage, and a similarity threshold is set. Five types of grain bulk temperature anomalies are then simulated. Additionally, a comparative experiment is carried out that considers traditional methods based on HSV feature similarity and local binary pattern (LBP) feature similarity. The results show that the average recall rates of the F-measures of the improved method, the traditional method based on HSV feature similarity, and the method based on LBP feature similarity are 96.2%, 89.3%, and 95.4%, respectively, and the processing speeds are 340, 300, and 690 ms per group, respectively. Finally, an abnormal grain temperature experiment is carried out. The experimental results show that the improved method can detect sudden changes in the temperature field due to mold activity or spoilage and the fluctuations in grain temperature caused by aeration.
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附件二：EI收录情况

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Authors:Cui, Hongwei (1); Wu, Wenfu (1); Wu, Zidan (1); Lan, Tianyi (1); Dou, Jianpeng (1)
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Language:Chinese
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Document type:Journal article (JA)
Publisher:Chinese Society of Agricultural Engineering
Abstract:Accurate detection of historical status of granary is helpful for its management. Based on statistical analysis of grain temperature in granary, this paper presents a method to detect the storage status of the granary in attempts to resolve the problem of time-consuming and tediousness faced by inventory inspection. Warehouse with state of being empty, filled with fresh grain and ventilation was used as an example. Analysis of the distribution of statistical characteristics of historical grain temperature showed that the empty warehouse could be detected using the difference in temperature between the upper and lower adjacent layers of the grain bulk as well as the variation of the grain temperature; the fresh grain could be detected by the difference in temperature between adjacent layers and the difference in standard deviation of the grain temperature; the ventilation could be detected by the change in the grain temperature and the standard deviation difference of the grain temperature. The threshold intervals of the characteristic parameters of the three states were set preliminarily from analysis of the statistical characteristics of the grain temperature. Based on the threshold intervals, three optimal levels were selected and the orthogonal experiments of two-factors and three-levels were designed. In the same grain depot with 11 granaries, new and ventilated granaries were chosen for the orthogonal experiments. The optimal threshold range of the statistical characteristic parameters were determined by analyzing the statistical characteristics of the historical grain temperature changes in the 11 granaries. Multi-variable decision tree for inventory status detection was designed and the optimal threshold of the characteristic parameters of the multi-variable decision tree were as follows. The temperature difference between adjacent layers for empty granary status detection was [-0.12, 0.12]℃. The temperature difference between adjacent layers was more than 0.02 (or 0.03)℃, and the standard deviation was less than 2.0 (or 2.1)℃. The average temperature change rate in the parameters for detecting the ventilation characteristics was [-0.5, 0.5]℃/d and the standard deviation change rate was [-0.21, 0.21]℃/d. Finally, seven granaries in different provinces were selected to test the detection method. The results showed that the accuracy and recall rates were 78% and 82% respectively for the empty granary state, and 74% and 70% respectively for new grain state, and 91% and 88% respectively for ventilated state. The test results showed that the proposed method detected granary at empty and ventilated state more accurate than at new grain state.
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Number of references:29
Main heading:Grain elevators
Controlled terms:Decision trees - Statistics - Ventilation - Warehouses
Uncontrolled terms:Detection methods - Optimal threshold - Orthogonal experiment - Standard deviation - Statistical characteristics - Status detections - Temperature changes - Temperature differences
Classification code:643.5 Ventilation - 694.4 Storage - 922.2 Mathematical Statistics - 961 Systems Science
Numerical data indexing:Percentage 7.00e+01%, Percentage 7.40e+01%, Percentage 7.80e+01%, Percentage 8.20e+01%, Percentage 8.80e+01%, Percentage 9.10e+01%
DOI:10.11975/j.issn.1002-6819.2020.02.037
Database:Compendex
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<RECORD 2>
Accession number:20192307005336
Title:Monitoring method of stored grain quantity based on temperature field cloud maps
Authors:Cui, Hongwei (1); Wu, Wenfu (1); Wu, Zidan (1); Han, Feng (1); Zhang, Na (1); Wang, Yujia (1)
Author affiliation:(1) College of Biological and Agricultural Engineering, Jilin University, Changchun; 130022, China
Corresponding author:Wu, Zidan(Wuzidan91@163.com)
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Issue date:February 15, 2019
Publication year:2019
Pages:290-298
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ISSN:10026819
CODEN:NGOXEO
Document type:Journal article (JA)
Publisher:Chinese Society of Agricultural Engineering
Abstract:A reliable method of grain storage supervision can effectively guarantee the quantity of grain storage in and out of warehouses according to plan and reduce the loss of unplanned entry and exit. In recent years, there has been a method of monitoring grain storage by video equipment, but the security of storage and management of video surveillance is poor and inconvenient to use. In this paper, we proposed a method for grain storage supervision based on the similarity of RGB color features of temperature field cloud map. Firstly, the historical grain data of the grain storage was called and pre-processed to remove the random code, error and other data. According to the correlation of the temperature at the adjacent temperature measurement points, the grain temperature data of each plane in the grain bulk was interpolated and the temperature field cloud map was generated. Then the similarity of the temperature field cloud map at the adjacent days was calculated by the similarity algorithm based on the RGB color feature distribution, similarity threshold was set according to the similarity of cloud maps during normal storage. Finally, the abnormal movement in the grain bulk was judged according to the similarity threshold. In order to verify the feasibility of grain storage regulation based on similarity of temperature field cloud map, five kinds of abnormal movement in grain bulk were simulated. The five kinds of abnormal movement respectively were: the half part of the grain bulk at right side and latter side, the quarter part of the grain bulk at right side and the latter side, and overall of the grain bulk. Similarity algorithm based on the RGB color feature distribution was used to detect abnormal movement of grain bulk. Meanwhile, the method based on the similarity of LBP texture feature was also used to compare with the method, the results showed that the mean of recall rate of the method based on the RGB color feature distribution was 98.6%, the mean of precision rate was 97.3%, and the operation speed was about 320 ms/time. The mean of recall rate of the similarity detection algorithm based on the LBP texture feature was 97.3%, the mean of precision rate was 96.2% and the operation speed was about 540 ms/time. The data were analyzed by analysis of variance, the results showed that the influence of anomaly types and temperature plane on recall rate was very significant and the influence of abnormal type on precision rate was very significant, and the influence of temperature measurement plane on precision rate was not significant. Taking into precision rate, recall rate and algorithm speed consideration, similarity detection algorithm of cloud map based on RGB color feature distribution was more suitable for the detection of grain storage supervision. The test of grain storage supervision was carried out, and the results showed that the algorithm can not only regulate the grain storage, but also detect the local heat in the grain bulk. The purpose of this study was to lay the foundation for a reliable and simple regulatory approach to grain storage regulation.
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Number of references:32
Main heading:Digital storage
Controlled terms:Color - Energy storage - Feature extraction - Grain (agricultural product) - Motion analysis - Security systems - Signal detection - Temperature - Temperature measurement - Temperature sensors - Textures
Uncontrolled terms:Cloud map - LBP textures - Monitoring methods - Rgb colors - Similarity - Similarity algorithm - Similarity detection - Similarity threshold
Classification code:525.7 Energy Storage - 641.1 Thermodynamics - 716.1 Information Theory and Signal Processing - 722.1 Data Storage, Equipment and Techniques - 723.2 Data Processing and Image Processing - 741.1 Light/Optics - 821.4 Agricultural Products - 914.1 Accidents and Accident Prevention - 944.5 Temperature Measuring Instruments - 944.6

Temperature Measurements
Numerical data indexing:Percentage 9.62e+01%, Percentage 9.73e+01%, Percentage 9.86e+01%
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<RECORD 3>
Accession number:20191906870532
Title:Reserves Monitoring Method for Grain Storage Based on Temporal and Spatial Correlation of Grain Temperature
Authors:Cui, Hongwei (1); Wu, Wenfu (1); Wu, Zidan (1); Han, Feng (1); Zhu, Haotian (1); Qin, Xiao (1)
Author affiliation:(1) College of Biological and Agricultural Engineering, Jilin University, Changchun; 130022, China
Corresponding author:Wu, Wenfu(wwfzlb@126.com)
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Issue date:January 25, 2019
Publication year:2019
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Language:Chinese
ISSN:10001298
CODEN:NUYCA3
Document type:Journal article (JA)
Publisher:Chinese Society of Agricultural Machinery
Abstract:The supervision and verification of grain bulks is an important segment during storage. Reliable reserves monitoring method for grain storage can effectively guarantee national grain quantity security. To solve the problems such as time consuming, labor cost and other problems in the manual audit of reserves, a monitoring method for grain storage quantity based on correlation analysis was proposed. Firstly, the autocorrelation and intercorrelation of the temperature measurement planes in the grain bulks were analyzed, so that the abnormal date and planes were detected. Secondly, the autocorrelation and the intercorrelation of temperature measurement lines in the abnormal date were analyzed, and the abnormal lines were detected in the abnormal date. Then the autocorrelation and intercorrelation of the temperature measurement points in the abnormal temperature line were analyzed. The number of abnormal points was counted, and the type of abnormal occurrence and the abnormal proportion were determined according to the number. At the same time, the granaries were selected in three storage grain areas: low temperature zone, medium temperature zone and high temperature zone for correlation analysis. According to the analysis results, the threshold of autocorrelation coefficient of temperature measurement plane was set to be 0.8, the threshold of change rate of intercorrelation coefficient was [-0.15 d⁻¹, 0.15 d⁻¹]; the threshold of autocorrelation coefficient of temperature measurement line was 0.8; and the autocorrelation coefficient of temperature measurement point was 0.8. Meanwhile, the analysis results showed that the correlation between temperature measurement lines and points in short period can not be used as an anomaly criterion. The supervision test of grain storage was carried out. The test results showed that the grain storage supervision method based on the correlation analysis can not only realize the reserves monitoring, but also detect the local heating and other anomalies of grain bulk. The purpose was to analyze the correlation coefficient of grain temperature data in the granaries of several different grain storage areas, monitor the quantity of grain and provide a theoretical basis for the analysis of grain data in different regions.
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Number of references:25
Main heading:Temperature measurement
Controlled terms:Autocorrelation - Correlation detectors - Digital storage - Grain elevators - Monitoring - Temperature - Wages
Uncontrolled terms:Autocorrelation coefficient - Correlation analysis - Correlation coefficient - Grain storage - Grain temperature - High temperature zones - Monitoring methods - Temporal and spatial correlation
Classification code:641.1 Thermodynamics - 694.4 Storage - 722.1 Data Storage, Equipment and Techniques - 912.4 Personnel - 921 Mathematics - 944.6 Temperature Measurements
DOI:10.6041/j.issn.1000-1298.2019.01.036
Database:Compendex
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The End

证书号第3452826号

发明专利证书

发明名称：一种基于等效积温的批式静止床粮食干燥过程测控方法

发明人：吴文福;崔宏伟;金毅;刘哲;韩峰;徐岩;张亚秋;陈中旭

专利号：ZL 2018 1 0281952.3

专利申请日：2018年04月02日

专利权人：吉林大学

地址：130000 吉林省长春市前进大街2699号

授权公告日：2019年07月12日　　授权公告号：CN 108680002 B

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局长
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国家知识产权局
2019年07月12日

其他事项参见背面

证书号第3389102号

发明专利证书

发明名称：一种基于积温计算的烘干房物料干燥过程控制方法

发明人：吴文福;崔宏伟;韩峰;徐岩;张亚秋;刘哲;金毅;陈龙;陈中旭;朱浩天

专利号：ZL 2018 1 0282205.1

专利申请日：2018年04月02日

专利权人：吉林大学;长春吉大科学仪器设备有限公司

地址：130000 吉林省长春市前进大街2699号

授权公告日：2019年05月24日　　授权公告号：CN 108518972 B

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2019年05月24日

其他事项参见背面

证书号第4116291号

发明专利证书

发明名称：一种基于粮温数据的粮仓历史库存数量状态检测方法

发明人：吴文福;崔宏伟;吴子丹;韩峰;徐岩;刘哲;兰天忆;王启阳

专利号：ZL 2019 1 0931095.1

专利申请日：2019年09月29日

专利权人：吉林大学

地址：130000 吉林省长春市前进大街2699号

授权公告日：2020年11月27日　　授权公告号：CN 110646049 B

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2020年11月27日

其他事项参见续页

证书号第3897966号

发明专利证书

发明名称：一种粮堆结露预测方法

发明人：吴子丹;崔宏伟;朱浩天;韩峰;徐岩;刘哲;王启阳;兰天忆
徐文;吴文福

专利号：ZL 2019 1 0626913.7

专利申请日：2019年07月12日

专利权人：吉林大学;长春吉大科学仪器设备有限公司;吉林工商学院

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