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Advances and Prospects in Machine Vision: a Critical Review Based on CiteSpace

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ABSTRACT. *In order to systematically analyze the development of machine vision, this article uses the citation visualization analysis software CiteSpace to analyze the relevant literature included in the CNKI journal database in 2010-2020 with "machine vision" as the key word, and draws out the research institutions and research on machine vision Personnel cooperation map, explaining the distribution of research forces in this field and scientific research cooperation; generating keyword co-occurrence network maps through CiteSpace, analyzing popular research areas of machine vision, and using keywords as the entry point, using software to generate keyword emergence The intensity meter and the machine vision Timeline view analyze its research hotspots, research frontiers and development trends.*

KEYWORDS: *Information visualization, Machine vision, Citespace, Knowledge map*

1. Introduction

Machine vision is a comprehensive technology, including image processing, mechanical engineering technology, control, electric light source lighting, optical imaging, sensors, analog and digital video technology, computer software and hardware technology (image enhancement and analysis algorithms, image cards, I/O Card etc.). A typical machine vision application system includes image capture, light source system, image digitization module, digital image processing module, intelligent judgment decision module and mechanical control execution module. [1]

The feature of machine vision system is to improve the flexibility and automation of production. In some dangerous working environments that are not suitable for manual operations or occasions where artificial vision is difficult to meet the requirements, machine vision is often used to replace artificial vision; at the same time, in the mass industrial production process, manual visual inspection of product quality is inefficient and inaccurate. Using machine vision inspection methods can greatly improve production efficiency and automation. Moreover, machine vision is easy to realize information integration, which is the basic technology to realize computer integrated manufacturing. [2]

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CiteSapce, or “citation space”, focuses on analyzing the potential knowledge contained in scientific research. It is a citation visualization analysis software that has gradually developed in the context of scientometrics and data visualization [3]. In the field of science, the citation distribution of literature information has a certain regularity, which is an important part of information metrology theory. At the same time, as a method, citation analysis has a wide range of applications. Therefore, the citation rules and citation analysis methods of literature information occupy a pivotal position in information metrology, and have important theoretical and practical effects. [4]

This article aims to use the dynamic network analysis information visualization tool CiteSpace, and take the “machine vision” as the sample in the CNKI database as a sample to visually analyze the research power in this field, and at the same time determine the research hotspots and research frontiers in the machine vision field And development trends.

2. Data Sources and Research Methods

Using the CNKI journal database, with the subject term “machine vision” as the search condition, select SCI source, EI source, core journal, CSSCI and CSCD as the source category. The search time range is 2010-2020, and a total of 4861 entries are obtained. As a result of relevant data, after excluding invalid documents such as news, conferences, notes, and book reviews, 4806 valid sample documents were obtained. Each data record includes information such as the title of the paper, author, author unit, abstract, keywords, references, journal year, etc. The data download time is June 7, 2020. In the measurement analysis, the year 2010-2020 is divided into 11 time periods for analysis.

It mainly uses the software CiteSpace commonly used in scientometrics to process the obtained documents, and mainly analyzes the research author group and the research institution. Describe the research situation of researchers and related institutions through indicators such as the number of articles and citations. In order to study machine vision hotspots and frontier focus areas, based on keyword-based co-occurrence network graph analysis, statistical frequency and betweenness centrality to identify research frontiers and related hot areas. Use keywords to highlight the knowledge graph to show the cutting-edge concerns in the field of machine vision. Combining hot technology and cutting-edge concerns, analyze the future development trend of the machine vision field.

3. Research Results Trends and r&d Force Distribution in the Field of Machine Vision

3.1 Document Time Distribution

The number of articles published can effectively reflect the popularity of research. The fluctuation of the number of publications can be used to predict the

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future development trend of this field, which is of great significance to scientific research. It can be seen from Figure 1 that the overall research on machine vision is heating up. From 2010 to 2020, the number of domestic related articles is on the rise, with the highest number of articles published annually at 828 and the lowest at 283. It can be predicted that this is related to the international manufacturing trend, "German Industry 4.0"[5], "Reindustrialization of the United States" and "Made in China 2025". Among them, the policy game between China and the United States may trigger another peak in 2020 [6-9]. From the perspective of the number of published documents, the number of published articles in the first half of 2020 has reached 287, and there will be more research results in the second half of the year. On the whole, from the perspective of the change trajectory of the amount of machine vision posts, machine vision related fields are still a hot research topic in the future.

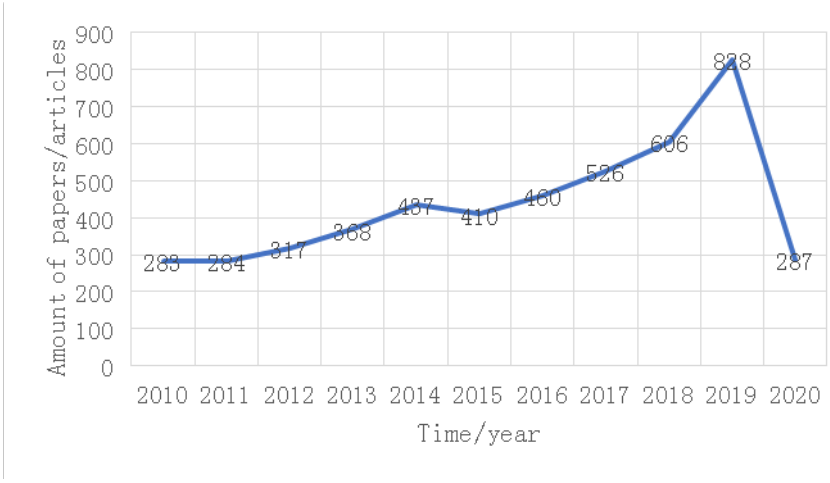

Fig.1 Distribution of Machine Vision Research Literature

3.2 Distribution of Research Institutions

Analyze the institutions involved in the collection of documents by drawing a cooperative map, and explore the most influential research institutions in the field of machine vision. In the cooperation map, the size of the node represents the number of published papers, the size of the node is proportional to the number of documents, and the network connection reflects the strength of the cooperative relationship.

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Table 1 the Ranking of the Number of Citations Issued by Machine Vision Research Institutions

citation counts	references	cluster #
53	Chinese Academy of Sciences University	4
50	College of Engineering, China Agricultural University	4
35	School of Mechanical and Automotive Engineering, South China University of Technology	4
35	Huazhong Agricultural University College of Engineering	4
35	School of Electrical and Information Engineering, Hunan University	5
35	School of Computer and Information, Hefei University of Technology	7
34	School of Engineering, South China Agricultural University	6
32	State Key Laboratory of Precision Testing Technology and Instruments, Tianjin University	5
31	Key Laboratory of Advanced Control of Light Industry Process, Ministry of Education, Jiangnan University	4
30	College of Engineering, Nanjing Agricultural University	4

Group clusters show the cooperative relationship between a research institution and other research institutions, and demonstrate the academic influence of research institutions. As shown in Table 1, the School of Computer and Information of Hefei University of Technology ranks sixth in the citation frequency, but it has the most clusters, indicating that it has a close cooperation relationship with other research institutions. By comparing the cluster cluster numbers of the top 10 research institutions in the number of publications in Table 1, it is found that the cluster cluster of the School of Computer and Information of Hefei University of Technology ranks first, followed by the University of Chinese Academy of Sciences and the School of Engineering of China Agricultural University. It can be seen that a high output rate does not necessarily have a wide range of cooperation relationships, and a higher cooperation rate generally means a high output rate.

4. Hot Spot Positioning, Cutting-Edge Concerns and Trend Analysis in the Field of Machine Vision

4.1 Hot Spot Positioning in Machine Vision

Research hotspot refers to one or more research topics that researchers are concerned about in a certain research field, which represents the mainstream research direction of the field. The CiteSpace co-word analysis can reflect the hot spots in the target field. [10] In order to better grasp the hot fields of machine vision research, and to grasp the research trends in the field of machine vision, it is

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convenient for related research institutions and researchers to quickly grasp the development trend of the field, and the keyword co-occurrence network map is generated through the CiteSpace measurement tool. It conducts quantitative and qualitative analysis, clarifies research hotspots, and provides meaningful reference suggestions for research in machine vision related fields.

Table 2 High-Frequency Node Information Table

keywords	count	centrality	keywords	count	centrality
machine vision	2240	0.26	target detection	87	0.12
computer vision	585	0.23	image identification	75	0.10
image processing	464	0.23	camera calibration	56	0.06
deep learning	253	0.07	template matching	47	0.07
convolutional ceural network	201	0.05	feature fusion	43	0.03
target tracking	126	0.10	three-dimensional reconstruction	42	0.06
feature extraction	124	0.17	machine learning	31	0.04
defect detection	112	0.06	artificial intelligence	29	0.03
edge detection	95	0.14	pattern recognition	18	0.05
support vector machines	93	0.14	principal component analysis	15	0.05

Centrality refers to the number of times that a node serves as the shortest path bridge between any two nodes, and it is a measure of the size of the connection that the node plays in the overall network. The greater the centrality of a node, the more times it acts as a “bridge” to pass data, and it is prone to congestion becoming the bottleneck of the network, but it also shows that the node occupies a key position in the entire network. [11] From the perspective of scientific measurement, the greater the centrality, the greater the influence and importance. [12] Therefore, centrality can be used to evaluate academic influence, that is, the higher the centrality of a certain keyword, it is an important node in the research field and an important “hub” for the development of this field. From Table 2, it can be found that the centrality of machine vision, computer vision and image processing is relatively high, which has a greater impact in the field of machine vision research.

Comprehensive frequency statistical analysis indicators and centrality indicators, to determine the technical hotspots in the field of machine vision are mainly concentrated in image processing, deep learning, machine learning, three-dimensional reconstruction and artificial intelligence.

4.2 Frontier Concern Recognition in the Field of Machine Vision

Table 3 lists the top 16 keywords in the field of machine vision research from 2010 to 2020. The keywords with strong emergence intensity include “deep

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learning", "convolutional neural network", "sparse representation", "image classification", "particle filtering", and "pedestrian re-recognition", etc. The frequency of change is relatively high, and it is the frontier of machine vision. Hot spot. The high frequency of emergence of "quality detection", "edge detection", and "camera calibration" indicates that it has also received a certain degree of attention in the field of machine vision, and is a series of research hotspots in the development of machine vision. At the same time, emergence rates such as "deep learning" and "convolutional neural networks" have been on the rise in the past three years, and they are the frontiers of machine vision research.

Table 3 the Highlighting Strength Ranking of Machine Vision Keyword Nodes

keywords	year	strength	begin	end	2010-2020
hough transform	2010	5.1483	2010	2013	
edge detection	2010	4.8252	2010	2011	
camera calibration	2010	5.0184	2010	2012	
agricultural products	2010	5.1779	2010	2011	
quality inspection	2010	4.8943	2011	2015	
bp neural network	2010	5.3001	2011	2015	
identify	2010	5.3347	2011	2014	
measuring	2010	4.8047	2012	2016	
particle filter	2010	5.0125	2012	2016	
image classification	2010	5.1673	2014	2017	
sparse representation	2010	6.1059	2014	2016	
labview	2010	4.4053	2014	2017	
image feature	2010	4.7077	2015	2017	
deep learning	2010	52.4256	2018	2020	
pedestrian re-identification	2010	4.5079	2018	2020	
convolutional neural network	2010	40.4318	2018	2020	

Synthesizing the difference between the emergence intensity and the emergence period, it is concluded that the frontier hotspots in the field of machine vision mainly focus on: artificial intelligence; deep learning; machine learning; image processing.

5. Conclusion

Based on the CiteSpace visual analysis software, this paper studies the literature related to machine vision in CNKI journals, analyzes and summarizes the research

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hotspots and frontiers in the field of machine vision from a quantitative perspective, and avoids excessive subjective qualitative analysis in the past research process. After analysis, it is found that the research in the field of machine vision can be divided into a slow growth stage and a rapid growth stage in terms of time. The distribution of researchers is not concentrated, and the research team and core author group are still developing. Research institutions are mostly universities. By analyzing the top ten research institutions in the number of published articles and citations, it is concluded that there is a certain relationship between cooperation rate and output rate. A large number of publications may not necessarily have a close cooperative relationship with other research institutions, and research institutions that are good at cooperating generally have a relatively high amount of publications. For keyword co-occurrence analysis, we have obtained predictions of hotspot technologies and concerns in the field of machine vision, which mainly focus on artificial intelligence, deep learning, machine learning, three-dimensional reconstruction and image processing. In order to better understand the specific technical context of a certain branch of the machine vision field, in the future, a visual analysis can be carried out for a specific technical branch to dig deeper into the development context of a certain technology. This series of analysis results can provide reference guidance and suggestions for the development of machine vision.

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