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Policy Regulation of Artificial Intelligence: A Review of the Literature

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Abstract. With the all-round penetration of new AI technologies into human society, the necessity of policy regulation is becoming more and more prominent. A review of the research results on policy regulation of AI in the West from 1992 to 2020 reveals that: the research on AI policy regulation is still in its initial stage, and researchers mostly use law, political science and management science as their research perspectives to enter the topic, and the research fields are becoming more and more diversified, but not closely connected; The research topics are still at the level of philosophical value and contingency, specifically, the value judgment of policy regulation, procedural mechanism, and ethical issues of medical application, and there are controversies among different scholars, but a basic consensus has been reached on the ethical concerns and regulatory necessity of AI. The future research trends of policy regulation of AI mainly include three aspects: multi-discipline, implementation and diffusion of policy regulation, and ethical reflection.

Keywords. Artificial intelligence, policy regulation, literature review

1. Introduction

Artificial intelligence is an emerging discipline that integrates diverse knowledge from computer science, philosophy and even psychology. As a branch of computer science, it is gradually being applied to various fields such as medicine, education and administration. The development of technology is often a double-edged sword, and while the development of AI and life changes are becoming intertwined, it also brings new problems. The break of ethics and the blurring of the public-private boundary[1] have challenged the basic rules and values originally set by human beings. To address the risks posed by the development of AI, policy regulation is necessary not only to prevent ethical issues arising from the development of AI, but also to enhance the applicability of AI in the field of public affairs. With the widespread application of AI in various fields, policy regulation of AI development by Western scholars has emerged.

Why should we care about policy regulation in AI? Because effective regulation of policies is more favorable to the development of artificial intelligence. Policy regulation is more flexible than legislation and can respond to changing situation, which makes it more effective than law in many cases and does not easily kill off many of AI's future possibilities.

This paper reviews the research results on policy regulation of AI development in the West from 1992 to 2020, showing the basic status of current research, hot topics, summarizing and sorting out research characteristics, and grasping future research trends.

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2. Research methods and sample

Bibliometrics is formed and developed by the application of mathematical and statistical methods to the field of library and intelligence, which takes various external characteristics of academic literature as the research object and uses mathematical and statistical methods to describe, evaluate and predict the current situation and development trend of the research field. With its user-friendly interface, strong data processing capability and powerful mapping function, CiteSpace has become a scientific knowledge mapping tool used more by scholars at home and abroad. In this paper, with the help of CiteSpace, we try to show the current situation and hot topics of policy regulation research on the development of AI in the West through the visual analysis of sample data, and make an outlook on the future.

Using the Web of Science core collection as the database, the search formula is shown in Figure 1, and 262 search results were obtained (as of April 17, 2020). The entries that were not relevant to the research topic were manually removed, and 255 documents were finally obtained after de-duplication.

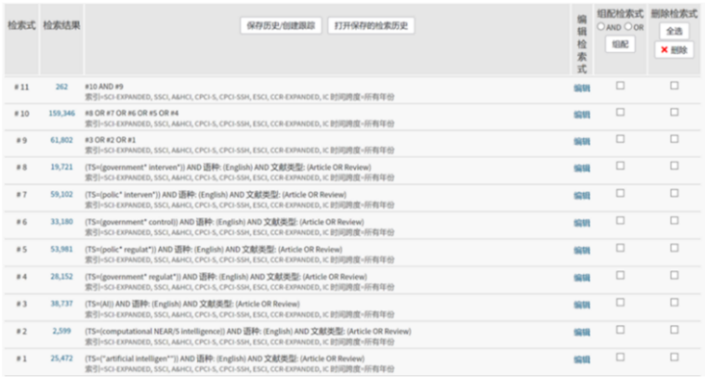

Figure 1. Search formula

3. Status of Research

3.1 The number of articles and journals

In general, Figure 2 shows that the research on AI development policy regulation has shown a proliferation trend in recent years. the number of articles published between 1992 and 2013 was low, but in 2014, the number of articles began to exceed 10, due to the continued rise of academic concern about AI development policy regulation on the one hand, and the dramatic changes in the AI field and breakthroughs in new technologies on the other. in 2014, Google, Facebook acquired several AI companies, Alpha Dog won the world Go championship, and breakthroughs in neuromorphic chip technology greatly unleashed the efficiency of machine learning software. Facebook acquired several artificial intelligence companies, Alpha Dog defeated the world Go champion, and the breakthrough of neuromorphic chip technology greatly released the efficiency of machine learning software. Technological development has brought about changes in industry and life, and has also attracted strong attention from academia.

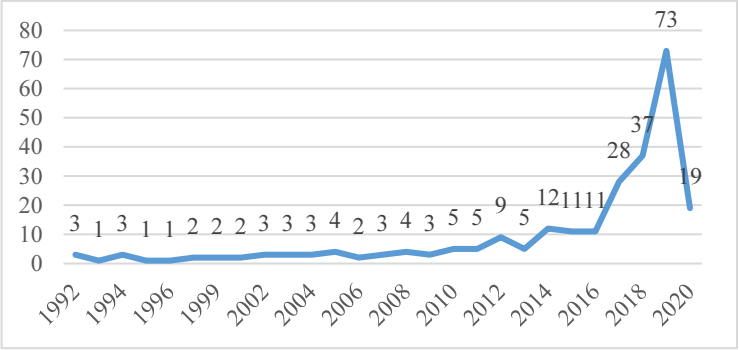

Figure 2. Number of papers per year, 1992-2020[2] (Web of Science core collection)

Table 1. Frequency of journals

Frequency	Journal	Frequency	Journal
35	SCIENCE	27	JAMA-J AM MED ASSOC
34	NATURE	21	LECT NOTES COMPUT SC
31	PLOS ONE	21	ARTIFICIAL INTELLIGE
29	NEW ENGL J MED	20	ARTIF INTELL
29	AM J PUBLIC HEALTH	20	COMMUN ACM

Table 1 shows that the top journals are mostly natural science journals such as science and medicine, and there are fewer social science journals such as management, political science and law, which can show from the side that the policy regulation research of AI development in the West has not been well integrated with related disciplines such as political science and public administration.

3.2 Countries and research institutions

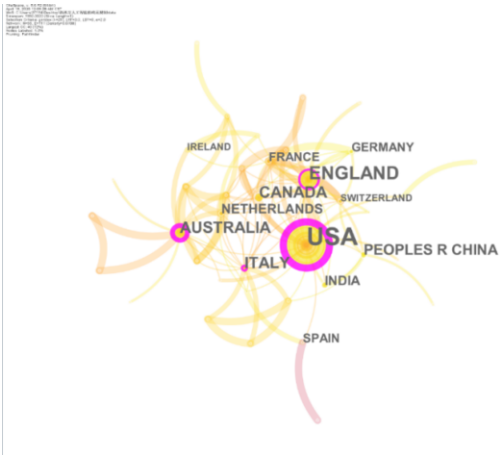

Figure 3. Co-presentation of country

[2] Since the data was only collected through April 17, 2020, the data of 2020 is incomplete and does not illustrate the downward trend.

Through the analysis of the co-occurrence and frequency statistics of countries, we found in Figure 3 that the United States, the United Kingdom, Canada, Australia, and Italy have more articles and more influence, with the United States ranking first with 98 articles, the United Kingdom ranking second with 33 articles, followed by Canada, Italy, and Australia with less than or equal to 20 articles. The academic center of gravity for AI development policy regulation research is still in the United States.

Table 2. Frequency of research institutions

frequency	research institutions	frequency	research institutions
6	Univ Washington	3	Georgetown Univ
4	Univ Oxford	3	Johns Hopkins Univ
3	MIT	3	Stanford Univ
3	Univ Hong Kong	3	Johns Hopkins Bloomberg Sch Publ Hlth

Statistics on the frequency of research institutions reveal in Table 2 that the main research institutions for AI development policy regulation are higher education institutions, such as the University of Washington and the University of Oxford ranked first and second with 6 and 4 articles respectively; higher education institutions such as the University of Hong Kong, Georgetown University, Johns Hopkins University, and Stanford University followed with 3 articles.

4. Research focus

4.1 Research perspectives and areas

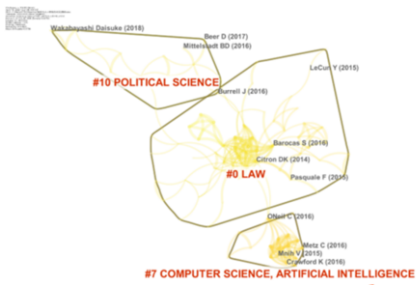

Figure 4. Clustering of research areas of co-cited literature

Research Perspectives. By clustering the research fields of the co-cited literature, it is obvious in Figure 4 that the co-cited literature mainly comes from three major fields: political science, legal science, and computer science. In other words, apart from computer science itself, political science and legal science are currently more concerned with the "regulation" of AI development, with political science favoring the perspective of government regulation and legal science favoring the perspective of legal regulation, with different theoretical sources and perspectives. For example, Baranov et al. analyzed the main problems and contradictions in the process of forming the legal system for the regulation of AI and other innovative technologies from the perspective of legal regulation, and proposed how to protect the legitimate rights and interests of individuals, society and the state through legislative settings and legal regulation[2], which is different from the perspective of governmental regulation theory.

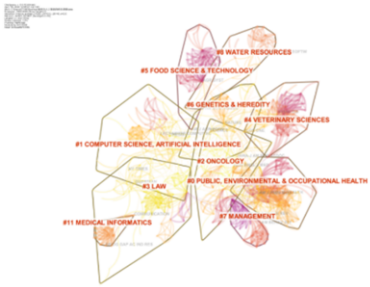

Figure 5. Clustering of research areas of journals

Research fields. From the clustering diagram of research fields in the journal, it can be seen in Figure 5 that the main research fields of AI development policy regulation are computer field, medical field, legal field and management field. In the field of computing, the main concern is how to regulate the ethical risks brought by big data[3]and algorithms[4][5]; in the field of medicine, according to the division of medical content, there are reflections on the regulation of AI development in each specific field; in the field of law[6] and management, researchers are more concerned about the impact caused by AI in the field of public affairs, and try to build a regulatory mechanism for AI development. In addition, AI technology is also used in the fields of environmental monitoring and transportation, and the research on regulation in each field is quietly emerging.

4.2 Hot topics

Table 3. Frequency of keywords

frequency	keywords	frequency	keywords
58	artificial intelligence	10	policy
15	avian influenza	10	impact
14	model	9	privacy
13	big data	9	chicken
13	machine learning	9	algorithm
13	american indian	9	intervention

Through the co-occurrence in Figure 6 and frequency statistics of the keywords in Table 3, in addition to “artificial intelligence” “policy” “regulation”, those including “big data” “machine learning” “algorithm” related to technology indicate that researchers pay close attention to the technological development in the field of artificial intelligence. Those including “intervention” “prevention” “management” related to government indicate the researchers' concern about the issue of government regulation of AI development. Those including “privacy” “impact” related to the rights of the individual indicate that the researcher reflects on the ethics and values of AI development. There are also some keywords related to the medical field, such as "avian influenza" and "disease", which indicate the first application of artificial intelligence in the medical field.

Figure 6. Co-occurrence of keywords

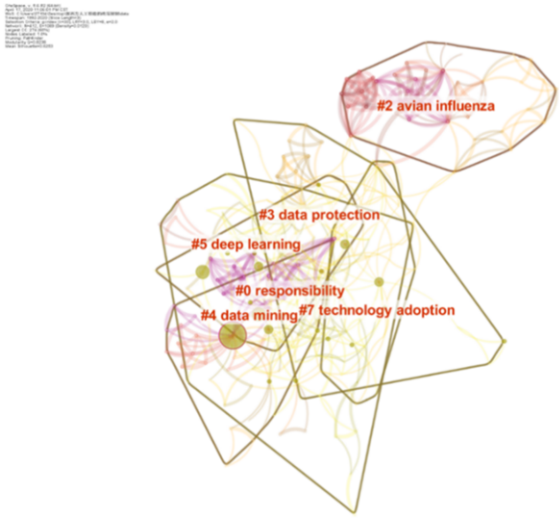

Figure 7. Keyword clustering

Table 4. Keyword clustering identification

clustering labels	SIZE	centrality	year	main keywords
#0	58	0.721	2015	responsibility; autonomous vehicles; transparency; privacy;
#2	40	0.977	2004	avian influenza; avian influenza virus; artificial intelligence; public health policies;
#3	37	0.792	2015	data protection; health policy; fda; ethical issues; other public health; global governance; management;
#4	33	0.832	2003	data mining; artificial intelligence; gradient method; formal concept analysis; interaction strength;
#5	24	0.834	2005	deep learning; internet of things; big data; surveillance;
#7	16	0.884	2016	technology adoption; process adaptation; mhealth; situation calculus; microfinance economy; cancer disparities; classical planning; machine ethics; ontology; behaviour change interventions;

Through clustering analysis of keywords in Figure 7 and reading specific literature contents in Table 4, we found that the hot topics of policy regulation research on the development of AI in the West mainly focus on value and ethical issues, and some articles try to build a regulation mechanism with the help of case experiences. In general, the topic selection is at the initial stage of philosophical value issue exploration, which is still at the level of contingency and not implemented to the concrete practice level. Specifically, there are three main aspects:

Value judgments in policy regulation. In the exploration of AI policy regulation, many scholars have discussed the value of the question of whether regulation is warranted. Some scholars have expressed concerns about the boundary issues of big data, especially the use of big data and human rights violations[7]. For example, Chatterjee Sheshadri et al. argue that personal data sharing is closely related to human rights issues in the era of the arrival of big data and discuss how human rights violations of personal data sharing can be addressed through the implementation of policy regulation[8]; In another article by Chatterjee Sheshadri, it is also discussed how policy regulation of artificial intelligence affects the strength of people's willingness to use robots, and the results show that strict regulation of AI is effective in increasing people's willingness to use robots[9].

However, some scholars have raised different opinions that government regulation of AI technologies is too strict. For example, Hoffmann argues that governments and nonprofit organizations have proposed a large number of ethical standards and regulatory constraints on AI development in recent years, but these challenges lack critical examination, creating many obstacles to the widespread use of AI technologies, and the regulatory approach needs to be urgently transformed[10].

Procedures and mechanisms of policy regulation. The necessity of policy regulation in the field of AI is recognized by most scholars, and on this basis, some scholars discuss the procedures and mechanisms of policy regulation. For example, Clarke suggested that in view of the riskiness of AI technology applications and the complexity of the political environment, joint regulation is recommended to regulate the AI field, and proposed the mechanism and procedure of relevant power allocation[11]; Buiten discussed the problem of AI, especially algorithm transparency, from three aspects of input data, algorithm holding and decision model, and proposed the technical operability and bias of the policy regulation procedure. The problem of bias is discussed in terms of three aspects: input data, algorithm holdings, and decision models, and the dual requirements of technical operability and acceptability for policy regulation procedures are proposed[12].

Similarly, there are some scholars who dispute the strictness of the policy regulation process, such as O'Sullivan, who argues that policy regulation should leave maximum space for AI technology development, otherwise it will stifle the innovation of AI technology[13].

Ethical issues when applied to medical treatment. The emergence of artificial intelligence was the first to bring about fundamental changes in human health care[14], with upgrades in technical means, but also the resulting issues of doctor-patient relationships, moral ethics and value judgments. A number of scholars have discussed the ethical issues of AI applications in the medical field[15] and proposed ideas on how to construct a regulatory mechanism. For example, Opderbeck believes that the future development of AI needs to be regulated and regulated whether in drugs, biological products, or medical devices, and proposes a regulatory model[16]; Harvey believes that the existing regulatory model is not sufficient to support the development of AI

technology in the medical field, and explores the history of FDA regulation of AI medical devices to provide a policy regulation of AI providing a new framework[17].

Another scholar takes a relatively optimistic view[18], with Kohli Ajay arguing that AI is the new wave of innovation in healthcare and that it has promising applications in all aspects of medicine. But despite this, the regulation and control of this technology remains a bottom-line issue, and he attempts to paint a new picture of AI policy regulation by citing the regulatory initiatives taken by the U.S. Food and Drug Administration in response to corporate mergers in the field of medical imaging[19].

5. Conclusion

In terms of research topics, the main focus is on ethical issues, which are at the initial stage of philosophical value exploration and still remain at the level of contingency, not yet implemented to the level of specific practice. On the issue of value judgment, most scholars express ethical concerns about the development of AI, while some scholars think that such concerns are too strict; on the issue of procedural mechanism, most scholars think that strict procedures should be established to regulate the development of AI[20], while others think that maximum space should be left for the development of AI; on the issue of ethics in medical field, some scholars are highly cautious about the application of AI in medical and health fields, while others are relatively optimistic and advocate moderate policy regulation. Despite this debate, there is a basic consensus among scholars on the ethical concerns and worries about the development of AI and the need for policy regulation in the field of AI.

This paper helps AI technicians to timely pay attention to the regulations of policies, laws, ethics and other aspects of technology, so as to avoid some future risks while developing technology. For the government, these studies provide some intellectual support for the government to make decisions, and help them timely adjust the regulatory policies and adapt to the situation.

The following are the main trends in future research on policy regulation of AI development predicted from the level of research perspectives and topics:

Interdisciplinary research. With the penetration of AI technology in all fields of production and life, the disciplines involved in AI policy regulation research are diversified. Although the specific regulatory procedures and mechanisms required by each field differ, a general regulatory framework is necessary; otherwise, the "siloed" character of current research will hinder the communication and progress of research and lead to self-talk. A general regulatory framework applicable to multiple disciplines will be the direction of future researchers' efforts.

The landing and proliferation of policy regulation. At present, the research is still limited to the discussion and debate in the philosophical scope of ethical values and other contingent levels, and some ideas have been put forward on the practical procedures and mechanisms of policy regulation, but with the full-scale practice of AI technology, the policy regulation practice should follow suit. The diversification of AI application fields has led to the proliferation of policy regulation practices in multiple fields. Research on the implementation and proliferation of policy regulation practices will become a future trend.

Ethical rethinking will continue. As research on AI policy regulation develops, the wave of ethical reflection will not abate, but will continue to rise as the technology develops. Ethical reflection on AI development is a constant reminder of the "double-

edged" nature of technology, and the fundamental philosophical issues that arise from technological development will not be lost in time. Ethical reflection on the policy regulation of AI development will continue in the future.

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