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From Traditional to Intelligent: The Development and Characteristics of Investigative Logical Thinking in the Context of Artificial Intelligence

Changming Feng[1]

[1] Henan Police College, Zhengzhou, Henan 450046, China

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Abstract

The application of artificial intelligence in criminal investigation has become a hot spot of theoretical and practical research, the core of which is reflected in the innovation of big data technology and machine algorithms on the investigation mode. This paper starts from the perspective of logical thinking, discusses the transformation of investigative thinking and its characteristics in the era of artificial intelligence, and aims to reveal the deep mechanism of the integration of traditional investigative logic and intelligent technology. The logical thinking commonly used in traditional investigation is mainly reflected in retrospective reasoning, scientific hypothesis and best explanation reasoning. The investigation in the era of artificial intelligence is facing new requirements and challenges, which makes the logical thinking in the investigation in the era of artificial intelligence present new characteristics, thus empowering the transformation of investigative logical thinking. By exploring the transformation of logical thinking in investigation empowered by artificial intelligence, it is urgent to build a "human-machine symbiosis" model, in order to play the core role of logical thinking in investigation and improve the legality, ethics and effectiveness of investigation work.

Keywords

artificial intelligence, investigation, logical thinking

1. Introduction

One of the hot points of current research in criminal investigation theory and practice is undoubtedly the exploration of the application and use of artificial intelligence in investigation, such as visual cognition, trace tracing, crime scene reconstruction, expert systems, etc., which have all received extensive attention. Broadly speaking, artificial intelligence includes big data technology and machine algorithms. Big data technology refers to the technology that rapidly collects, stores, integrates, refines, and analyzes massive data, mines the valuable information contained in the data, and efficiently and accurately assists in practical applications. It generally includes technologies such as big data perception and acquisition, big data storage and management, big data analysis and mining, big data retrieval and application, and big data security, etc. Among them, big data analysis and mining is the core part, because the value of big data is realized through analysis and mining. And the intelligence value derived from big data technology has brought new opportunities for the development of the criminal investigation field, leading to the birth of the big data investigation model. As a new type of investigation means, the emergence of big data investigation has its objective reality needs. Especially in the modern construction of public security, a high degree of integration and efficient analysis and mining of public security law enforcement big data can be realized through big data technology, laying a solid foundation for intelligent case handling, intelligent supervision, intelligent assessment and intelligent management. Besides, machine algorithms also play an important role in investigation. Through data comparison, iris recognition, model analysis and other ways to promote crime tracking, crime identification, crime prediction and many other functions in the investigation, thus greatly improving the efficiency of the investigation. With the development of artificial intelligence, generative artificial intelligence has widely affected all aspects of society through the application of large models. In investigation, artificial intelligence-enabled investigation will certainly help to accurately assess the reasonableness of relevant evidence, construct reasonable assumptions in line with the reality of the case, improve the efficiency and effectiveness of handling and concluding relevant cases, as well as realize the prevention and prediction of crime.

Although the above studies have achieved certain results, if the logical thinking involved is not explored, these discussions will not be able to go deeper into its essential level, summarize its results at an abstract level, and gain an in-depth understanding of the characteristics and features of the transformation of the logical thinking of the investigation. In view of this, it is necessary for us to carry out research on logical thinking in investigation in the age of artificial intelligence. And it is essential to promote the in-depth development of logic in the applied disciplines, and provide guidance for the dilemmas faced by the discipline of investigation in the age of artificial intelligence in terms of the way of thinking and the thinking methodology of the ideas, so as to realize an important role in the detection of cases and crime prevention.

2. Characteristics of Traditional Investigative Logical Thinking

Although the era of artificial intelligence has arrived, and there is a big change in the way and method of investigation, but the traditional investigation logical thinking still has its value and role, and continues to play its due application value in the era of artificial intelligence. Therefore, we still need to explore the characteristics of the traditional investigation logical thinking, aiming to grasp the traditional investigation logical thinking way and method and carry out a good human-computer interaction in the era of artificial intelligence. Based on previous research, we summarize the logical thinking commonly used in investigation as retrospective reasoning, hypothesis and best explanation reasoning, which are also the characteristics of traditional investigative logical thinking.

2.1 Retrocausal Reasoning

Retrocausal reasoning is an important method of exploring causal links. It is a mode of reasoning that starts from a known fact or result and constructs a reasonable sufficient condition hypothetical judgment of the affirmative posterior, thus presuming the affirmative antecedent. From the perspective of deductive logic, it is clear that this is not a valid form of logical reasoning and does not guarantee that the conclusion will necessarily be reached. Although its conclusion does not have the characteristics of inevitable true, the conclusion reached is contingent, but in scientific discovery, innovative thinking has an important role, but also reflected in the investigation of the thinking practice process. Retrospective reasoning was first proposed by the American philosopher Charles Sanders Peirce. He used it as the third type of reasoning alongside deductive and inductive reasoning. And he pointed out that “Retrocausal reasoning is a process of forming explanatory hypotheses.” () That is to say, retrocausal reasoning explores the connection from the result to the cause or the known fact to the unknown conditional reason, and proposes an appropriate and reasonable explanation. “Retrocausal reasoning is essentially a hypothesis (conjecture) about why a phenomenon exists in the particular way it does, whether that phenomenon is a natural object or event or human behavior.” (Randy LaPolla & Yao, 2023) In public security practice, retrospective reasoning is manifested in the process of determining the basic facts of the case and identifying the suspect, which involves the whole process of filing a case, investigating the scene, collecting evidence, identifying the suspect, and determining the basic facts of the case. It is well known that this is contingent reasoning from a deductive point of view, but it is consistent with the process of our practical reasoning, our everyday reasoning, and is therefore characterized by proper conformity. (Gui & Xie, 2018) For example, in the case of the disappearance of student Hu, the reason for his disappearance is inferred by means of homicide, suicide, accident, etc., and the investigative work is carried out with the help of multiple parties looking for definite evidence, and it is finally determined to be a disappearance. This reflects the basic characteristics of retrospective reasoning, that is, inferring the cause from the facts of the case. In the era of artificial intelligence, the investigation work can be collected with the help of information with great breadth and depth, but a lot of investigation work is carried out after the occurrence of the case. There is a certain lag, which requires retrospective reasoning to the case, the person, the matter of reasoning, aiming to identify the

facts of the case. Even if the video tracking work, it still need to determine the direction of investigation to carry out the relevant work, and the determination of the direction of investigation depends on the retrospective reasoning. And “To achieve generalized artificial intelligence, one needs to be able to mimic the way humans create meaning, which depends on the ability to reason retrospectively.” (Randy LaPolla & Yao, 2023) This suggests that retrocausal reasoning will still need to be used in the future development of artificial intelligence in the practical application of detection.

2.2 Hypothesis

Hypothesis, that is, usually based on general knowledge or objective facts, on the phenomenon or the cause of the event or other unknown facts put forward beyond the scope of the premise of the hypothetical explanation and description of the process. The investigative hypothesis is the hypothesis or inference of the investigator in the case of mastering the facts of the case, in order to detect the case in the investigative practice, using the previous investigative experience or investigative theory of the case involved in the things, people and things. (Zhang, 2021) The specific process of the investigative hypothesis contains three steps of investigative hypothesis formulation, inference and verification. That is to say, according to the limited case information, and based on the past theory, experience, common sense and so on, the investigators should carry out creative thinking, put forward the investigation hypothesis, and then through the investigation of the case, gradually verify the hypothesis, adjust the process of hypothesis. Among them, the process of verification requires the use of relevant deductive reasoning, such as trinitarianism, hypothetical reasoning, selective reasoning and other related content. And hypotheses, by their nature, are contingent. The same is true for investigative hypotheses, which are not guaranteed to be absolutely correct. Only through verification, can confirm the truth or falsehood of the hypothesis, so as to achieve the purpose of understanding objective things. The investigative hypothesis is directed at the facts of the crime, and the act of investigation that requires the investigation to be concluded within a specified time limit needs to be subject to legal procedures. “The investigative hypothesis has the two dimensions of factual determination and legal determination.” (Chen, 2014) The formulation of the investigative hypothesis lies in the unearthing and analyzing of doubts in a case. The thought process of speculation should be reasoned by investigators with limited information at their disposal seeking to restore the truth of the facts and the process of their occurrence. Sometimes it is also related to the investigator’s intuition, which forms a reasonable hypothesis by forming a connection between the case and the truth in an intuitive way. In the case of investigative hypotheses, work is carried out to confirm or falsify them, thus verifying the truthfulness of the hypothesis. This involves the evaluation and trade-offs of investigative hypotheses, that is, the question of their explanatory power, which requires attention to optimal explanatory reasoning.

2.3 Inference to the Best Explanation

Inference to the Best Explanation (IBE; some researchers also use the term best illustrative reasoning; this paper does not distinguish between the two) is “a type of illustrative reasoning that yields hypotheses” and is also “a strategy for selecting the correct illustration from potential illustrations.”

(Wang, 2013) That is to say, among the competition of multiple hypotheses, based on evidence, we recommend the best hypothesis that can explain the facts. G. Harman (1965) states, "when one starts from this premise, that a known hypothesis will provide a 'better' account of the evidence compared to other hypotheses, then one can launch the conclusion that the known hypothesis is true." That is, faced with a limited number of known facts, it is necessary to formulate alternative hypotheses, and then to follow up on these hypotheses from the evidence to carry out a relative judgment of good or bad. In the practice of investigation, the best explanation reasoning refers to the process in which investigators propose multiple hypotheses about a case based on existing evidence and experience, and deduce a highly accurate narrative of the crime scene as the evidence is accumulated. And such a narrative is logically characterized by acceptability, comprehensibility, and fidelity, thus allowing for a better explanation of the case's reality. In testing the investigative hypothesis, "the testing function of best explanatory reasoning can be used in the factual organizing procedure in the mid-investigation or end-of-investigation stage." (Pan & Wu, 2024) In the examination of cases, the principle of best explanation reasoning, as a crucial principle, can most reasonably interpret various types of evidence, particularly the primary evidence, thereby maximizing the restoration of the case's truth and forming a complete and rigorous chain of evidence. In other words, the best explanation reasoning ensures the authenticity and validity of the reasoning, and by constructing a reasonable case reconstruction scenario, it clearly, explicitly, and truthfully presents the entire process and facts of the case, matter, and person, thereby persuading judges, parties, investigators, and others. This will builds a process close to the real scene restoration, aiming to reasonably explain the occurrence and development of the case, and accurately and clearly figure out the basic facts of the case, which can powerfully avoid the occurrence of false and erroneous cases. For the investigation, it is necessary to explore the case, the matter and the person in the case of certain evidence, and it is essential to have a definite and accurate conclusion.

The above reasoning, which plays an important role in the investigation, shows the universality of the investigation thinking, reflecting the thinking characteristics of investigators in the actual investigation work. With the advent of the era of artificial intelligence, investigators are facing new challenges in terms of methods and means of thinking, which are mainly reflected in the change of thinking.

3. The Opportunity to Transform Investigative Thinking in the Era of Artificial Intelligence

Artificial intelligence technology is an important element in the competition between countries in recent years and a new engine for economic development, which has an important role and value for social governance and national security. The arrival of the era of artificial intelligence means that the breadth and depth of the amount of data has reached a certain level, the amount of data has grown exponentially, and the data available to draw on has been greatly enriched. At the same time, machine algorithms are also changing people's thinking methods and habits of thought, both predicting human behavior and changing people's behavior, which are also bound to have an important impact on investigation. Based on this, we mainly explore the challenges and opportunities encountered by the

investigation in the era of artificial intelligence under the perspective of logic, mainly from the perspective of logical thinking.

The great abundance of online information has facilitated people's work and life, and also given criminals an opportunity to take advantage of it. As a result, illegal and criminal behaviors such as gun-related, drug-related, pornography-related, and fraud-related are also lurking in cyberspace with the development of the network, and even illegal and criminal activities are carried out under the private cyberspace. And these have brought new challenges to crime fighting work. The meaning of this sentence is, in other words, that the mere mastery of past technical means is not enough to deal with today's criminal facts, the need to re-examine the way the development of crime occurs. This requires both the provision of quantifiable predictions based on data analysis, leading to a big data investigative mindset ranging from accuracy to relevance, and data mining capabilities to make progress in obtaining information. In addition, along with the development of modern society, people's socio-economic activities are inevitably traced on telecommunication devices, jitterbugs, microblogs, Weibo, WeChat, QQ and other media. And the collection and arrangement of these network traces will be able to reflect the various trajectories of specific individuals and organizations, thus sketching a character portrait. From the perspective of logic, to ensure the effectiveness and accuracy of investigative reasoning, it is necessary to collect enough data to carry out intelligent analysis and manual screening and verification, which then becomes effective information for case detection.

Detection in the age of artificial intelligence inevitably involves the algorithmic problem of data and artificial intelligence-assisted reasoning. Artificial intelligence helps investigators understand, analyze, and use data, thereby changing their previous understanding of data, and ultimately helping them achieve panoramic investigation, predictive investigation that predicts the future, and algorithmic investigation that utilizes data models. Artificial intelligence can also be based on massive data to help investigators establish analysis models to predict criminal behavior and occurrence, and to deploy police in advance to prevent criminal behavior. Therefore, this requires investigators to carry out advanced pre-judgment and police forecasting based on the thinking characteristics of artificial intelligence, such as full data, complexity, and relevance, in order to change traditional investigation methods, form new judgments and understandings of criminal behavior, and predict possible harmful social behavior, thereby maintaining social security and stability. With the improvement of intelligence, machine algorithms can provide early warning information, intelligent warning of possible violations of the law, so as to improve the accuracy and effectiveness of the investigation. As for the early warning information, it is also necessary for investigators to conduct manual screening and checking, followed by the need to feedback and improve the reliability and accuracy of the algorithm. This also puts forward new requirements for the knowledge update and knowledge learning of investigators.

The exploration of investigation in the era of artificial intelligence needs to strengthen the application of logical thinking and investigation in the context of artificial intelligence, in order to absorb the results of logic research in the new century. It is essential to enhance its transformation and innovation

in the investigation in the context of artificial intelligence, and then play the important role of logical thinking in the investigation in the context of artificial intelligence.

4. The Characteristics of Artificial Intelligence-enabled Investigative logic Thinking Transformation and Its Application

The first step in investigative thinking in the era of artificial intelligence is to analyze the thinking characteristics of investigative logic in the era of big data. Viktor Mayer-Schönberger, the father of big data, has summarized big data thinking, "First, it is necessary to analyze all the data related to something, rather than relying on analyzing a small number of data samples. Second, we relish the complexity of data and no longer seek precision. Finally, there is a shift in our thinking away from exploring elusive causality and toward focusing on the correlations of things." (Viktor Mayer-Schönberger, 2013) This is a generalization of big data thinking from the three aspects of data quantity, data quality, and correlation.

4.1 Thinking Characteristics of Investigative Logic in the Big Data Era

On the basis of Viktor Mayer-Schönberger, Wang R. (2017) put forward the problem of logical thinking in big data investigation and analyzed the logical thinking in big data investigation, namely relevance, wholeness, and prediction. The first is relevance. In the process of investigation, we should rely on the richness of the data, starting from the need to detect the case, to find relevant information, thereby determining the direction of the investigation, suspects, and other key details, which serve as part of the investigation and evidence. In other words, this is an interpretation problem of behavioral relevance based on correlational information, that is, only seeing the relationship but not knowing what causes it. This also requires police officers to make reasonable explanations to form a complete chain of causal evidence. The second is holism. The holistic perspective means that the investigation process should be viewed from the perspective of all data. To characterize this as a kind of thinking is to see the richness of information about the case, people, and events related to the case, which can be shown in all aspects. The third is prediction. The so-called prediction is the process of preventing the occurrence of crime or stopping the occurrence of crime in a timely manner by taking the police front in advance based on the hot spots of past cases, data abnormal performance, etc. on the possible occurrence of crime. The predictive way of thinking, with the development of machine algorithms and the abundance of data, allows investigators to predict the probability of crime occurrence in potential crime areas and the likelihood of recidivism in advance, thereby effectively preventing criminal activities and minimizing losses to the people.

4.2 Methods for Artificial Intelligence-Enabled Transformation of Investigative Logical Thinking

In the era of artificial intelligence, investigative logical thinking needs to be aided by analytical artificial intelligence and generative artificial intelligence. Analytical artificial intelligence uses mathematical models and algorithmic rules to analyze data, thus providing decision-making information. Analytical artificial intelligence can help investigators carry out case detection and early

warning in terms of abnormal information, data collection and analysis. It also can help effectively expand the thinking of investigators, and seize favorable opportunities for case detection through keyword correlation, whereabouts track correlation, and so on, so as to quickly solve the case. In recent years, generative artificial intelligence has made great progress. Generative artificial intelligence is capable of producing text that resembles human-written content by acquiring and utilizing vast amounts of text generated by humans, thereby composing new literary works. In terms of investigation, generative artificial intelligence, by interpreting legal texts and their conditions of application, can help investigators in the process of handling cases to recognize cases, people, and events, and improve the legal quality and logical literacy of investigators.

4.3 Application of Artificial Intelligence-Enabled Transformation of Investigative Logical Thinking

It is necessary to build a professional investigative database, relying on artificial intelligence experts to establish data models (such as Bayesian networks, knowledge mapping, deep learning), to promote the development of intelligent public security. In addition, artificial intelligence can assist in identifying and reconstructing elements of a crime scene (such as reasoning about the time, method, and motive of the crime) through data collection, feature quantification, and analysis. Only by using a sufficient amount of high-quality and anonymized cases to construct a specialized corpus (including case texts, legal provisions, and expert analysis records), and by regularly training specialized large investigative models, can artificial intelligence truly assist investigators in carrying out their work and provide them with reference suggestions or solutions for investigative tasks.

As we all know, today's artificial intelligence is still weak artificial intelligence, and can not replace the investigators to work and take responsibility. Compared to investigators, artificial intelligence still has a significant gap in terms of counterfactual reasoning, necessitating the involvement of investigators in specific investigative work. Because artificial intelligence can not break through the data, rely heavily on data quality and quantity, can not carry out innovation. Nevertheless, the ability for counterfactual imagination is a fundamental characteristic of human reasoning. In other words, humans possess the capacity for counterfactual thinking, meaning that we can envision alternative or opposite scenarios, thereby engaging in creative imaginative associations. It is evident that the ability for counterfactual thinking continues is play a crucial role in the investigative work of detectives. Due to the inability of data correlation to replace legal causal evidence in identifying the causes and effects of a case, a combination of traditional investigative thinking and artificial intelligence thinking is necessary. In other words, it is imperative to ensure logical rigor through the integration of human and machine intelligence, thereby forming legal causal reasoning and a complete chain of evidence. Ultimately, a dual-drive model combining data and intelligence, characterized by a "human review + machine assistance" approach, should be established to achieve a complementary fusion of human and machine capabilities. Therefore, we should establish an iterative closed-loop of case-data-model (such as optimizing algorithms through feedback from actual combat operations), driven by both data and intelligence, in order to achieve a new paradigm of human-machine collaborative investigative thinking.

The application of artificial intelligence in public security investigation needs to take data quality and human-machine synergy as the core, and through the simultaneous construction of professional large models and legal and ethical frameworks. It is necessary to realize the leap from "weak artificial intelligence assistance" to "strong artificial intelligence symbiosis", and ultimately promote the investigation work from "experience-driven" to 'data-intelligence dual-wheel drive' transformation.

"In terms of the method of intelligent simulation, today's artificial intelligence mainly takes a deductive path to the processing of data; it mainly takes statistical induction and probabilistic algorithms on data for uncertain problems, and lacks causality and correlation exploration." (Du, 2020) That is to say, there is still a need to explore the causality and correlation in the investigation in the era of artificial intelligence, to carry out explanatory work, and to explore where the reasons behind it lie.

5. Conclusion

The further development of artificial intelligence will inevitably lead to the development of logical thinking exploration in investigation. The discussions on formal argumentation and advancements in algorithms in recent years have facilitated the further development of investigative thinking in the era of artificial intelligence. Therefore, the practical and theoretical circles should combine efforts to jointly promote the exploration of logical thinking in investigation during the age of artificial intelligence, thereby advancing research on logical thinking in investigation against the backdrop of artificial intelligence.

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