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Article

Computational Jurisprudence Approach to the Analysis of Legal Liability for the Protection of Intellectual Property Rights in the Creation of Virtual Reality Content

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Abstract: Based on the computational jurisprudence method, this study gradually completes the scrutiny of the use of computational jurisprudence method from constructing the computational jurisprudence problem, obtaining the legal data in the creation of virtual reality content, selecting the appropriate data analysis model, and then testing and evaluating the model results. And the research idea based on the legal responsibility of intellectual property protection in virtual reality content creation was designed, and for the practical results, the steps to verify the correctness of the results were designed. The results of the research are as follows: when the length of the legal text of intellectual property protection is 600, the model of this paper has the best analyzing effect, and the accuracy rate, precision rate, checking rate, and F1 score are 0.870, 0.887, 0.831, and 0.858, respectively. The score values of the knowledge patent leakage risk indicators "Data Confirmation and Provision Risk", "Data Transmission and Reception Risk", and "Data Storage and Use Risk" are 3.40, 3.35, and 3.51 respectively, and the overall leakage risk level is level 4. The digital copyright attribution boundary score for virtual reality content creation is 2.73, which means that the determination of intellectual property attribution is somewhat controversial. Both computational jurisprudence methods and national economic levels can improve the level of intellectual property protection in virtual reality content creation.

Keywords: computational jurisprudence; data analysis modeling; test evaluation; virtual reality; intellectual property protection

1. Introduction

Virtual reality industry is an important force leading the new round of global industrial change, which will pry up the emerging market of trillions of dollars and become a new growth point of economic development [1]. Since the digital economy is different from the traditional tangible assets represented by physical objects such as land and property, but mainly intangible assets centered on intangibles such as patents, logos, copyrights, etc., whether the virtual reality industry can develop rapidly and orderly and healthily depends on the intellectual property rights owned by enterprises [2-5]. Intellectual property rights are as the basic means to stimulate innovation, the basic guarantee of innovation driving force and the core elements of international competitiveness, while the protection of intellectual property rights is an important factor whether the function and role of intellectual property rights can be realized [6-8]. If the risk of infringement is high, the difficulty of defending the right is high, to a large extent, will reduce the enthusiasm of investors to invest in the “virtual reality” industry, inhibit investors' large-scale investment and long-term investment, and ultimately will not be conducive to the long-term development of the industry [9-11]. If the infringement risk is small, the cost of rights defense is low, the burden of proof is weak, and the trial cycle is short, then it is conducive to the large-scale and continuous influx of capital, which is conducive to the scientific and technological personnel and creators to concentrate on research and creation, and ultimately is conducive to the vigorous development of the entire virtual reality industry [12-14].

At present, China's judicial field lacks judicial constraints on the creation of virtual reality content without clear regulations, and there are great differences in the academic community on the attribution of intellectual property rights of virtual reality content creation, with different perceptions of the legal nature [15-16]. This leads to different results and means in the judicial community in dealing with related cases, and numerous arguments among enterprises about the ownership of the intellectual property rights of creation, which is not conducive to the development of the virtual reality industry [17]. Therefore, it is important to clarify the relevant legal responsibilities of the intellectual property rights of virtual reality content creation in order to promote the legislation on the protection of intellectual property rights of virtual property, to make up for the legal gaps caused by the legal lag, and to provide certain references for the subsequent research.

This paper discusses in detail the key to defining infringement of content creation in virtual reality environment, based on which the infringement is categorized into direct infringement and indirect infringement. In addition, it clarifies the key steps to examine the use of computational jurisprudence in intellectual property protection, including the use of statistical techniques to clarify the computational jurisprudence problem, combining the cost and relevance of the problem and other factors to select the legal data, and then selecting the appropriate data analysis model and testing and analyzing the model results. Based on this, a case study on the legal liability of intellectual property protection in virtual reality content creation is designed to quantify the legal liability of intellectual property in terms of the risk of leakage of patented technology and the analysis of digital copyright attribution.

2. Definition of Copyright Infringement in Virtual Reality Scenarios

If it is presumed that a VR publication does not constitute fair use or legally licensed use, the next step should be to pinpoint the specific type of infringement. Copyright infringement is divided into direct infringement and indirect infringement. Generally speaking, under the premise of excluding fair use and statutory licensing, if another person infringes on the exclusive rights enjoyed by the copyright owner due to the copyright law without the authorization of the copyright owner of the original work, it is a direct infringement. For abetting, inducing or providing substantial assistance to the direct security behavior of others is indirect infringement. In virtual reality scenarios, the key to distinguishing whether the behavior of the original work is “borrowing” or infringement lies in whether the mode of behavior is creative, i.e., whether there is an artistic expression of the author's originality.

Infringement is divided into direct infringement and indirect infringement according to whether the infringer's behavior directly infringes the copyright of the right holder. In virtual reality scenarios, direct infringement takes various forms. First, some unauthorized virtual reality games or applications are one of the common forms that cause direct infringement. Second, the production team that creates the virtual reality content may have a problem with direct infringement. In addition, manufacturers of virtual reality devices may also be involved in direct infringement. Manufacturers of virtual reality devices need to ensure that the works used have been authorized by the copyright owner when providing pre-installed games or apps for their devices.

Indirect infringement of copyright in virtual reality scenarios is mainly manifested in the fact that network service providers or suppliers of VR hardware facilities know that a third party can use the services provided by them to carry out direct infringement when providing services such as "network access services", "information storage services" and "information location services". In fact, the network access services and information storage services provided by network service providers or VR hardware facility providers are objectively necessary conditions for the infringer to commit the infringement and the consequences of the infringement. As such, they inevitably constitute "substantial assistance to another person's direct infringement". However, it is difficult to simply classify such acts as indirect infringement, because if the network service provider or the supplier of VR hardware facilities commits direct infringement on the infringer's use of the service, there is no subjective fault.

3. Steps for Reviewing the Use of Computational Jurisprudence Methods

The computational jurisprudence method [18] is a new method of jurisprudence research aimed at solving specific jurisprudence problems. The method uses the existing computer methods and computer capabilities to develop the computer capabilities needed to achieve the goal, and then use this capability to achieve a specific goal, and feedback and correction of computer capabilities through the degree of achievement of the goal, the entire operation of the computer jurisprudence method needs to integrate computers and jurisprudential thinking. Computational jurisprudence method is a kind of mixed research method, it is intermingled with the absorption of qualitative and quantitative, normative and empirical methods, to form a composite, open-ended construction.

Computational jurisprudence method has uniqueness. On the one hand, it can deal with a large amount of data and information at one time. The large amount here refers to the quantity far exceeding the quantity that can be handled by human beings with bare hands, and also refers to the quantity that can be handled by hand with high efficiency. The computational jurisprudence method is no longer satisfied with the random sampling method because of its ability to handle large amounts of data and usually performs full sample analysis. On the other hand, the computational jurisprudence approach deals with large amounts of data primarily through computers rather than manually. It therefore requires that the assessment facilitator be able to communicate with the computer, understand how the computer is functioning, and translate the large amount of data to be processed into commands that the computer can understand and execute.

3.1. Building Clarity on Issues of Computational Jurisprudence

The use of computational jurisprudence to study legal issues follows the basic steps of legal empirical methods, and the whole process consists of four steps: problem selection, data collection, empirical analysis, and drawing conclusions, which is also the general steps of statistical research.

The use of computational law method to study legal data need to first construct the problem, computational law method and statistical methods have a greater connection, but the expression of the problem involved in computational law and statistics “hypothesis - test” expression is obviously different. Hypothesis testing is a testable proposition about an unknown relationship between variables, or understood as a tentative description of the relationship between variables. Hypothesizing is the process by which researchers formulate standard propositions about the relationships between “unknown” variables in advance. Hypotheses in this context are not value assumptions that scholars may bring into normative analysis, nor are they underlying assumptions that exist prior to the research question. Hypothesis testing is divided into theoretical hypotheses and working hypotheses. Unlike qualitative research, any theoretical statement in empirical analysis is eventually transformed into testable working hypotheses, and only the working hypotheses can be actually tested by the researcher. Researchers carry out proposition construction to complete the transformation of theoretical hypotheses to working hypotheses, and the appropriate degree of hypotheses and propositions depends on the empirical researcher's own business level and the quality of the selected research data.

3.2. Access to Legal Data

Data is the most basic element of the computational law method, and the acquisition of legal research data and data structuring is a necessary stage in the application of the computational law method. The way researchers acquire legal research data and the principles they follow in acquiring data will affect the quality of the data to the greatest extent. When researchers choose data acquisition methods, they should combine the cost, quality, relevance of the problem, and size of the data set as much as possible, and also follow the following principles:

First, the knowledge of the research topic is appropriate, before starting to collect data, the researcher should have a certain understanding of the research topic, but also should not bring their own fixed viewpoint preconceptions.

Secondly, the process of data collection should eliminate interfering factors and other influences other than the selected variables.

Third, the data acquisition method needs to have a large data capacity.

Fourth, the contradiction between informatization and standardization should be dealt with, and the data collection process is a process in which the researcher receives information from the research subject.

3.3. Selecting a Data Analysis Model

Computational models provide the technical basis for the realization of computational jurisprudence, which is also the fundamental reason why computational jurisprudence is different from traditional measurement jurisprudence. In the stage of legal data collection and structured expression, the researchers on the choice of what kind of computational legal analysis model should have produced the basic judgment, after the completion of data collection and structured expression, computational legal research that is to enter the stage of the computer model to analyze the data. In this process, the workload of researchers is significantly reduced, the computational model will exclude the intervention of the researcher to the greatest extent possible to complete the process of automatic identification, automatic analysis, automatic mining, results export, and finally through the computational modeling operation to present the results of data analysis. Based on the data analysis results, the researcher can adjust the model parameters for the computer to reanalyze the data, and can also make explanations for the problems under study based on the data analysis results. Of course, if the conclusions are clearly contrary to legal common sense, the data analysis results can be discarded, and the process can be repeated after making appropriate adjustments to the research data or re-selecting the computational model.

3.4. Testing and Evaluation of Model Results

Empirical testing is the “quality inspector” of whether the empirical research is successful and effective, computational jurisprudence is a kind of legal empirical research method for legal big data, the importance of testing and evaluation is self-evident. At this stage, researchers can assess the effectiveness of data analysis based on the test parameters provided by the computational model itself, and can also optimize the parameters in the model by examining the results of the model analysis, and re-introduce the data analysis model until a satisfactory result is obtained. If the examination of model analysis results is invalid or no law can be obtained after optimization, researchers should reconsider whether there are big problems in data quality, problem expression, and model selection. The essence of the computational model is a computer code with specific functions, these codes to achieve the function is to seek the law between the data, and the method of finding the law is obtained from mathematical disciplines, including probability theory and mathematical statistics, space vector computation, trigonometric functions and other basic mathematical theories, and the basic idea of the test theory is to indicate the reliability of the results of the calculations through the size of the probability.

4. Study Design

This study first identifies legal data sources for intellectual property protection in virtual reality content creation, followed by corpus construction and abstraction of a language model, and then validation data inputs for verification that the data conforms to the syntax of the jurisprudence.

4.1. Data Sources

In this paper, the first step is to establish a corpus of intellectual property rights, the data source of the corpus mainly comes from two parts, the first part is the laws and regulations related to intellectual property rights, and the second part is the virtual reality creation content documents and codes related to a company's internal design system. The detailed data source catalog is as follows, the first part is laws and regulations:

(1) Law of the People's Republic of China on the Protection of Intellectual Property Rights.

(2) The Interpretation of the Supreme People's Court on Several Issues Concerning the Application of the Law on the Protection of Intellectual Property Rights (I).

(3) The Interpretation of the Supreme People's Court on Several Issues Concerning the Application of the Law on the Protection of Intellectual Property Rights (II).

(4) The Interpretation of the Supreme People's Court on Several Issues Concerning the Application of the Intellectual Property Protection Law (III).

(5) “Supreme People's Court on the application of” Intellectual Property Protection Law “on a number of issues of interpretation (IV).

The second part of a company's internal design system related to the virtual reality creation of content documents and code:

(1) A company's internal system design documents and codes that do not violate laws and regulations relating to intellectual property rights.

(2) The special agreement on exemption of liability recorded in the insurance policy of a company.

4.2. Modeling

4.2.1. Text Pre-Processing

This paper requires preprocessing of the acquired text. The most difficult part of the preprocessing implementation path is word separation, word normalization and removal of deactivated words, which is also the core of text preprocessing. The core problem solved by Chinese participle technology is how to recognize a word, usually, there are two kinds of Chinese participle technology:

One is the dictionary-based Chinese participle, that is, the rule-based Chinese participle, the dictionary-based Chinese participle is the need to build a dictionary, through the matching of the dictionary, and then go to the division of the sentence.

The other one is the statistical Chinese word separation, which is considered as a problem of maximizing the probability. Based on the corpus, we can calculate the probability that neighboring words can form a word, and then divide the words according to the probability. First, a language model is needed. The second step is to divide the sentences to form phrases. The results of the divided words are then placed in a specific statistical method and their probability is calculated, obtaining the probability that the way of dividing the words is the largest. To avoid these words from affecting the model as well as the final result, the deactivated words can be removed during preprocessing.

4.2.2. Corpus Construction

According to the language of the corpus, the corpus can be categorized into monolingual corpus, bilingual corpus and multi-language corpus. In this paper, to solve the specialized problems, only Chinese is needed, the establishment of the Chinese monolingual corpus. This paper establishes a corpus using the tool Ant Conc.

4.2.3. Language Models

Syntactic analysis, its main task is to identify the syntactic components in a sentence, which it contains. The relationship between these syntactic constituents is identified, and the result of syntactic analysis is generally represented in the form of syntactic tree. There are two main problems facing syntactic analysis, one is that the Chinese language is so profound that there are many problems of multiple meanings of words, which need to be disambiguated. The second is that usually, a large amount of data support is needed to accomplish a syntactic analysis task. Different syntactic lengths require different amounts of data, and often the search volume demand is extremely high.

Based on the fact that Chinese syntactic structure itself is different, so its syntactic calculation methods are also different, so the first step needs to understand the internal structure of syntax first. Nowadays, there are two common syntactic relations: dependency syntax and phrase structure syntax. Of course, there are other syntactic systems as well. Phrase structure grammars can have different hierarchical levels, and they all articulate the relationship between automata, syntax and language.

4.3. Model Validation Steps

Based on the above discussion, the preliminary preparations, algorithms and tools involved are already known, and the formal design of the validation model is now carried out:

(1) Input the text formed by a given sentence and a given participle, and take the result of the participle as a loop to parse each participle.

(2) Judge whether there are words in the corpus after each clause is parsed, if so proceed to the next step, if not return to the first step (1).

(3) Determine whether there is a preposition inside the clause, if it does not contain a preposition, return to (1) and proceed to the next clause parsing, if it contains a preposition, it means that the clause is a simple sentence, go to (4).

(4) Repeat the above parsing of (2) and (3) for simple sentences until all parsed are simple clauses.

(5) Recognize the parsed participles from the validation data, take the first one, the first two, the last one, the last two participles and compare them with the example participles in the corresponding positions in the corpus, and get the result of whether it is a hit or not.

5. Analysis of the Protection of Property Rights in the Creation of Virtual Reality Content under the Computational Jurisprudence Approach

5.1. Performance of Legal Text Analysis for Intellectual Property Protection

There are cases of varying sentence lengths in legal texts, and by organizing the dataset, the maximum length of the query instrument in the instrument data inputted by the model is 973, the shortest length is 155, and the average input length is 618.In order to validate the model's validity in a variety of legal text scenarios, the maximum length of the text input in the dataset is taken as a variable, and the input length of the legal text, N, is set to 200, respectively, 300, 400, 500, 600, 700 and 800, calculate the accuracy rate, precision rate, check all rate and F1 score of the model's validation indexes under different text lengths, and get the experimental results of different input lengths as shown in Figure 1.

From the experimental results, when the instrument input is 600, the evaluation indexes of the model reach the best, and the accuracy rate can reach 0.870, the precision rate is 0.887, the check all rate is 0.831, and the F1 score is 0.858. With the reduction of the maximal input length, the performance of the model all decreases. When the maximum sentence input length is 200, the accuracy rate is 0.715, the precision rate is 0.724, the check-full rate is 0.694, and the F1 score is 0.709. This indicates that the truncated text contains a large amount of important information about the text matching, and thus the model is less effective when the input text is short. As the text length is elevated, the evaluation index measure of the model does not increase but decreases, and when the maximum sentence input length is 800, the accuracy rate is 0.816, the precision rate is 0.865, the check-full rate is 0.767, and the F1 score is 0.813, which is due to the fact that the text length of the dataset is more often around 600, and when N=800, the supplementary information does not enhance the model.

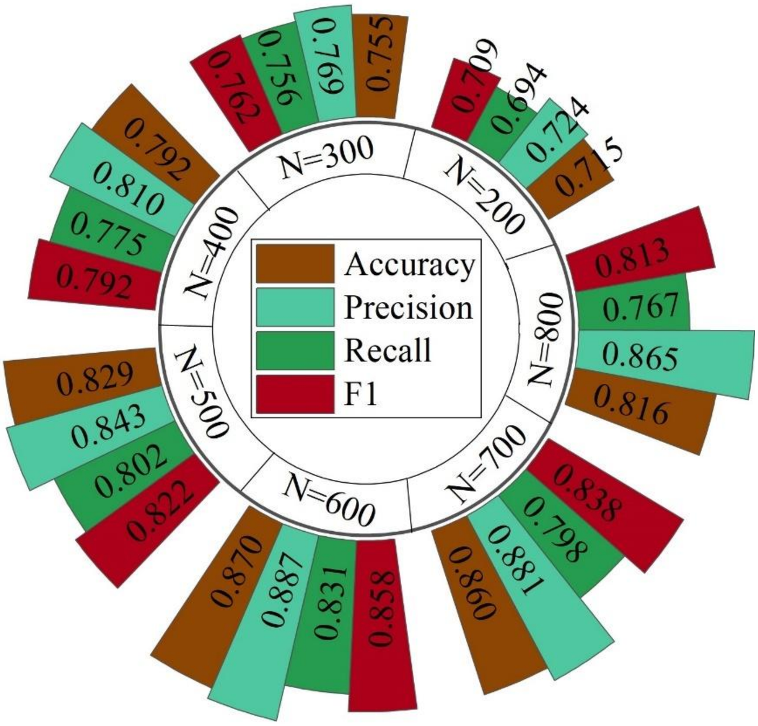

Figure 1. Experimental results of different input length.

5.2. Quantitative Analysis of the Risk of Knowledge Patent Leakage

This section constructs the risk indicators of patent technology leakage in the cross-platform data flow of VR created content from virtual reality content creators, industry analysts, and legal experts, including "data confirmation and provision risk" (A1), "data transmission and reception risk" (A2), and "data storage and use risk" (A3). This paper explores the risk of intellectual patent leakage in virtual reality content creation under the method of computational law.

Among them, the second-level indicators in "data confirmation and provision risk" include: data legitimacy (A11), data necessity (A12), data sensitivity (A13), and data compliance (A14).

The secondary indicators in "Data Transmission and Reception Risk" include: Transmission Security (A21), Contractual Completeness (A22), Receipt Legality (A23), and Receipt Compliance (A24).

The second-level indicators in Data Storage and Use Risk include: storage security (A31), processing legitimacy (A32), use legitimacy (A33), and rights and interests protection (A34).

Table 1 shows the statistical and calculated results of the risk constraint layer obtained by using the multi-level analysis method. It can be seen that the weights of "risk of data confirmation and provision" (A1), "risk of data transmission and reception" (A2), and "risk of data storage and use" (A3) are 0.643, 0.251, and 0.106, respectively.

Table 1. Statistical and computational results of the risk constraint layer.

	A1	A2	A3	Normalized weight
A1	1	3	2	0.643
A2	1/3	1	3	0.251
A3	1/2	1/3	1	0.106
Maximum eigenvalue=4.372,CI=0.039				
CR=0.047				

Taking the first-level indicator of “Risk of data validation and availability” A1 as an example, the statistics and calculations at the second-level indicator level are shown in Table 2. As can be seen, for the indicators under “Risk of data validation and provision”, data legitimacy has the highest weighting value of 0.472.

Table 2. Statistical and calculation results of the secondary index layer.

	A11	A12	A13	A14	Normalized weight
A11	1	2	2	3	0.472
A12	1/2	1	2	2	0.251
A13	1/2	1/2	1	3	0.176
A14	1/3	1/2	1/3	1	0.101
Maximum eigenvalue=4.875,CI=0.053					
CR=0.043					

Similarly, the weights of each level 1 indicator and the level 2 indicators under it were calculated and summarized as shown in table 3. Using this summary, the weighted scores for each indicator were calculated as follows.

Table 3. The secondary index and the secondary index weight.

Primary indicator	Weight	Secondary indicator	Weight	Composite weight
A1	0.643	A11	0.472	0.303
		A12	0.251	0.161
		A13	0.176	0.113
		A14	0.101	0.065
A2	0.251	A21	0.117	0.029
		A22	0.156	0.039
		A23	0.419	0.105
		A24	0.308	0.077
A3	0.106	A31	0.278	0.029
		A32	0.362	0.038
		A33	0.205	0.022
		A34	0.155	0.016

The legal risk evaluation results of the cross-platform flow of virtual reality creation content data are categorized into five levels, and values are assigned to each level by setting the evaluation set V={level 1, level 2, level 3, level 4, level 5}. The set of evaluation scores corresponding to the evaluation set is U={1, 2, 3, 4, 5}. Different risk levels correspond to different legal risk scenarios, and the higher the risk level, the greater the likelihood of a data cross-platform flow security event.

This paper collects the opinions of relevant practitioners, industry analysts and legal experts through questionnaires, and weights the risk factors based on case analysis, as shown in Figure 2. It can be seen from the figure that the investigators' scores for each secondary index are between 3~4 points. Combined with the above weights, the weighted scores of "data confirmation and provision risk" (A1), "data transmission and receipt risk" (A2) and "data storage and use risk" (A3) are 3.40, 3.35 and 3.51, respectively, and the overall patent leakage risk score is 3.40*0.643 3.35*0.251 3.51*0.106=3.40. The legal risk of intellectual patent leakage under the computational legal method belongs to Level 4.

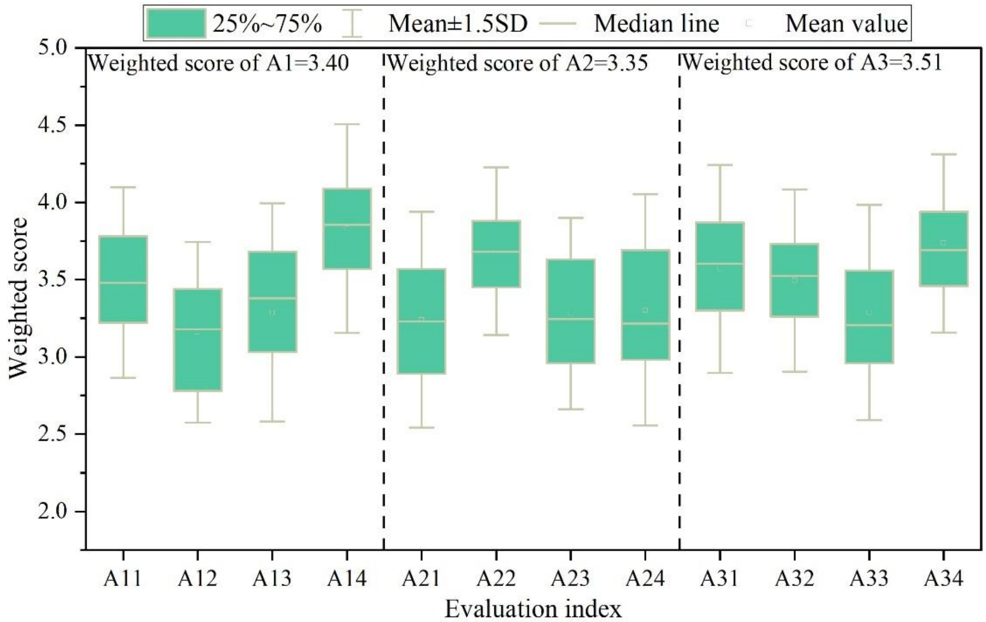

Figure 2. The membership score of each indicator.

5.3. Analysis of Liability for Digital Copyright Attribution

Virtual reality creates, shares and exchanges a huge amount of data that exists, covering many forms of digital content such as text, images, audio and video. However, it is due to the open and decentralized nature of the metaverse and the rapid development of digital technologies that the reproduction and distribution of digital content has become easier than ever. In the traditional copyright system, the owner of copyright can be easily identified due to the existence of a physical carrier for the work, but at the present stage, most of the works in the meta-universe space are non-physical works, only a string of numbers, which makes it impossible to identify the subject of copyright.

This section uses a questionnaire survey to quantitatively analyze the boundaries of digital copyright ownership in virtual reality content creation. The survey dimensions include "ownership clarity", "legal compliance", "technical protection measures", "industry recognition" and "exclusivity" of virtual reality content, and 50 investigators engaged in related research were invited to score the above dimensions from 1~5 points. The higher the score, the more obvious the digital copyright boundary is, and the easier it is to determine ownership.

The results of the investigators' scores for each dimension were calculated and summarized, as shown in Figure 3. The data in the figure shows that the average score of the investigators for the above dimensions is between 3~4 points, and the average scores of the five dimensions of "ownership clarity", "legal compliance", "technical protection measures", "industry recognition" and "exclusivity" are 2.65, 2.76, 2.80, 2.94 and 2.52, respectively. The overall digital copyright ownership boundary score is 2.73 points, which is in the lower middle level, indicating that there are certain difficulties in determining the ownership of intellectual property rights in content creation in virtual reality. The specific difficulties are: first, most of the works created in virtual reality are jointly created by users and artificial intelligence, and it is difficult to judge the fundamental rights of their works. Secondly, the reproduction and modification of digital works in virtual reality have become extremely convenient and easy due to the development of technology, and it is possible to create and reproduce works comparable to the original work, and the use of these technologies has made it difficult to protect the copyright of digital works created in space to a certain extent. Due to the continuous development of artificial intelligence, especially the construction of neuronal systems, artificial intelligence has achieved self-development to a certain extent, and can contribute more to human production and creation.

As virtual reality continues to evolve, AI applications will become more numerous and broader in scope, both in terms of language modeling and actual intelligent processing, and these applications will be able to create content that is different from what has been created in the past as they evolve, but the protection of digital copyrights for digital works created by the big models themselves is still very much a matter of debate.

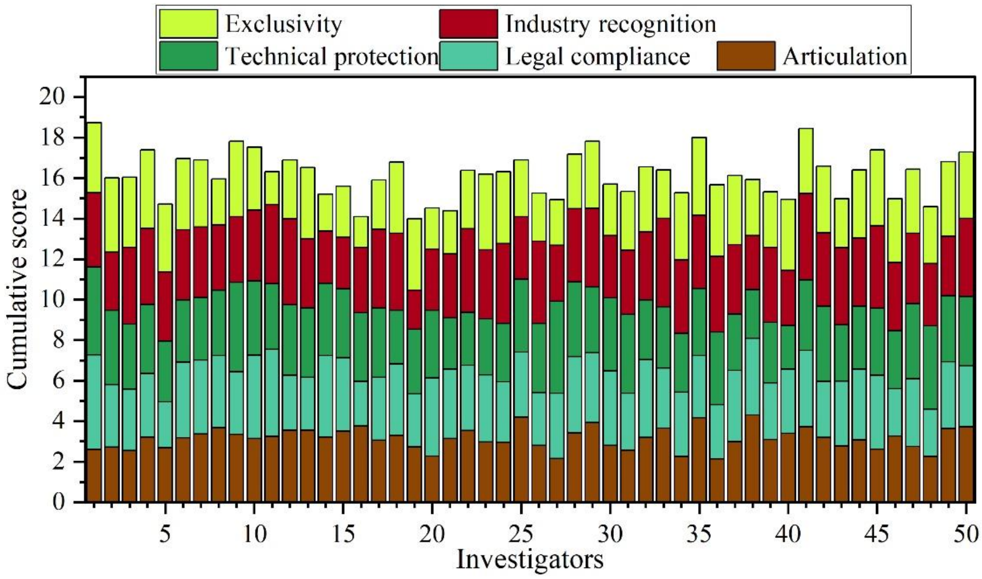

Figure 3. The researchers rated the dimensions of each dimension.

5.4. Trends in the Level of Intellectual Property Protection under Computational Jurisprudence

This section constructs indicators of the level of intellectual property protection for virtual reality content creation, including the scope of patent protection, the number of members of international agreements, the patent term, and the enforcement mechanism. Each scoring indicator is in a horizontal relationship, and the unweighted total value of each scoring item in each year constitutes the sequence of the index of the level of intellectual property protection of virtual reality content creation. In the paper, the maximum value of all intellectual property protection level indexes is assigned as 1, and the value of each index is added and multiplied by 5/4 to keep the total score of intellectual property protection index stable. The study statistically analyzes the intellectual property protection level of virtual reality content creation in the past 10 years, from 2015 to 2024, and obtains the results of the intellectual property protection level score of virtual reality content creation as shown in Figure 4.

It can be seen that the level of intellectual property protection for virtual reality content creation has gradually increased in the past 10 years. Comparing with 2015, the scores of the indicators of patent protection scope, the number of members of international agreements, patent term, and enforcement mechanism are 0.27, 0.30, 0.22, 0.46, respectively, and the comprehensive intellectual property protection level is obtained as (0.27+0.30+0.22+0.46)*5/4=1.563. By 2024, the scores of the above indicators are 0.89, 0.98, 0.94 and 0.91, and the same calculation gets the comprehensive intellectual property protection level of 4.650 points. It indicates that with the development of computational jurisprudence, the level of intellectual property protection for virtual reality content creation has a significant enhancement effect, and the former significantly improves the efficiency and adaptability of the latter through the combination of technological means and law.

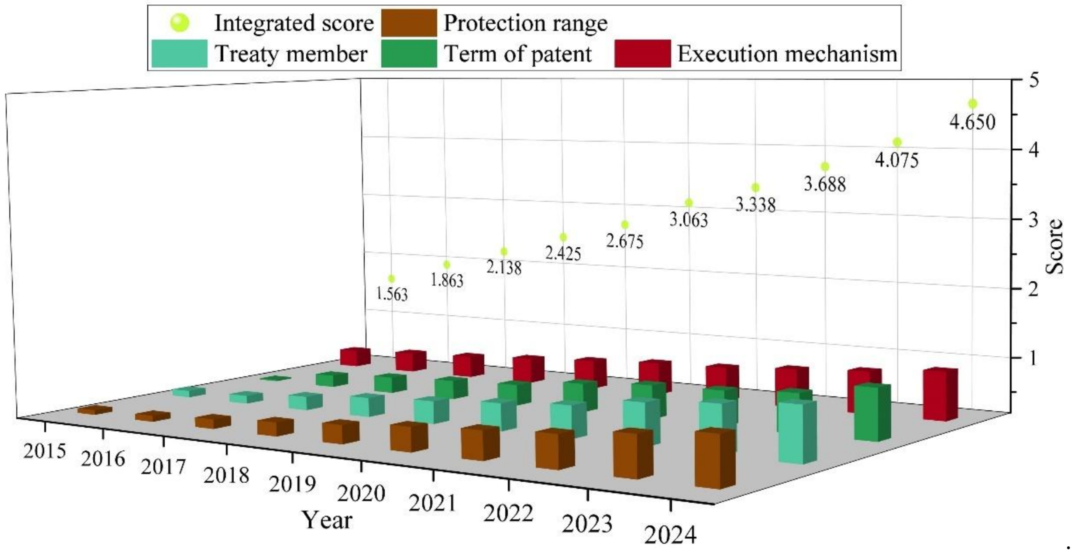

Figure 4. Intellectual property protection level score.

In order to substantiate the possible impact of computational jurisprudence (comlow) on the level of intellectual property protection in virtual reality content creation, this subsection further explores the Granger causality between the variables. In addition, the study employs aggregate GDP data (lgdp) to reflect the impact of the economic dimension on the level of intellectual property protection (lippindex) in virtual reality content creation.

Before the regression analysis, the smoothness test of the data series is conducted first, and the method used in the study is the augmented Dickey Fowler method, which is used to test the equations that do not contain a constant term and a trend term, that contain a constant term but do not contain a trend term, and that contain both a constant term and a trend term, respectively:

$$\Delta x_t = \alpha + \theta_t + \vartheta x_{t-1} + \sum_{i=1}^{t} \gamma_i \Delta x_{i-1} + \rho \varepsilon_t \quad (1)$$

where α is the intercept term, θ_t is the trend term, ε_t is white noise, and t is the lag. The test parameters ϑ are judged using the McKinnon asymptotic p values.

Based on the null hypothesis of the existence of a unit root, the test is conducted for the level and difference values of each series of data in turn, and the results of the Masuwadiki Fowler test are shown in Table 4. From the table, it can be seen that all the series have unit root at 5% level of significance and are non-stationary series. After first-order differencing, comlow and lippindex are significant at 1% level and lgdp series are significant at 5% level.

Table 4. Stability test results.

Variable	Adf	Critical value			P	Conclusion
		1%	5%	10%		
comlow	-2.935	-3.871	-3.081	-2.713	0.0712	Unsmoothness
△comlow	-3.116	-3.882	-3.085	-2.715	0.0131	Smoothness
lgdp	-1.537	-3.871	-3.081	-2.713	0.6447	Unsmoothness
△lgdp	-2.719	-3.882	-3.085	-2.715	0.0472	Smoothness
lippindex	-1.974	-3.871	-3.081	-2.713	0.3195	Unsmoothness
△lippindex	-2.435	-3.882	-3.085	-2.715	0.0005	Smoothness

Granger causality test examines the causality in the statistical sense on the premise that the data series have a cointegration relationship, under the premise that the introduction of other variables (including lag) can improve the degree of explanation of the variable by its own lagged value, then it can be determined that there is a Granger causality from the other variables to the variable. As can be seen from the foregoing, the data series of innovation results, the data series of economic fundamentals and the data series of the level of intellectual property protection are all of order single-integration, with cointegration, and the Granger causality test is used to examine the Granger causality between the variables as shown in Table 5.

From the test results, the following conclusions can be drawn: national economic fluctuations (lgdp) and the level of computational jurisprudence (comlow) at the same time constitute the Granger cause of changes in the level of intellectual property protection (lippindex). When the country's economic growth is strong and IPR protection is strengthened, both of them will promote the increase of innovation rate, and the level of computational jurisprudence (comlow) will increase with the level of economic development.

Table 5. Granger causal test output result.

Dependent variable	variable	F value	Proh>F value
comlow	lgdp	1.873	0.2751*
	lippindex	3.441	0.0746
	ALL	4.096	0.0539
lgdp	comlow	1.178	0.3696
	lippindex	0.649	0.5187
	ALL	1.884	0.3071
lippindex	comlow	3.763	0.0329*
	lgdp	3.325	0.0475*
	ALL	5.732	0.0053*

6. Conclusion

The article defines the infringement of content creation in the virtual reality environment and proposes a method of analyzing legal liability for intellectual property protection based on computational jurisprudence. Combining statistical methods to establish hypothetical propositions and clarify computational jurisprudence issues. Under the premise of following multiple principles, high-quality legal data integrating cost, quality, and relevance of the problem are collected. The research problem is then analyzed, interpreted and explained by selecting an appropriate model. Finally, the test and evaluation of the model results are carried out to improve the reliability of the results. Combined with the designed research ideas, the legal responsibility of intellectual property protection in virtual reality content creation is analyzed.

For legal texts of intellectual property protection of different lengths, the model in this paper obtains the best analysis performance when the length is 600, and the accuracy and other indicators are measured between 0.83~0.89. The risk evaluation index score of intellectual patent leakage is between 3.35~3.51, and the comprehensive leakage risk score is 3.40, and the leakage level belongs to level 4, which is relatively safe. The average score of indicators such as "clarity of ownership" and "legal compliance" is 2.73, which makes it difficult to determine the ownership of property rights. The level of intellectual property protection increases with the computational jurisprudence, and the comprehensive protection level will reach 4.65 points in 2024.

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