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Construction Method for Knowledge Graph of Driving Behavior under Adverse Weather

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Abstract

Weather condition are important factors affecting vehicle driving; However, the existing research results of weather factors on vehicle driving behavior are relatively scattered, and it is difficult to make effective decision analysis. Knowledge graph is one of the mainstream forms of knowledge base organization, which can clearly express the complex relationships between different objects. Therefore, introducing knowledge graph into driving behavior management is of great significance to improve decision-making ability. This study analyzes the characteristics of driving behavior affected by weather, and constructs the knowledge expression model of "weather condition–environmental condition–driving behavior". On this basis, a representation method based on characteristic value is proposed, and then the driving behavior knowledge graph is constructed. This method can clearly express the comprehensive relationship between weather condition and driving behavior, and provide support for vehicle driving behavior decision under complex weather condition. We take the existing relevant standards in the field of Meteorology and road traffic laws and regulations as examples to verify the practicability of the method. It lays a foundation for the construction of the knowledge graph of weather factors affecting driving behavior for autonomous vehicles in the future.

Keywords: Adverse weather, Knowledge graph, Driving behavior, Autonomous driving

1. Introduction

Adverse weather condition not only affect people's daily lives, but also have an impact on road travel safety; Adverse weather has become an important factor affecting road traffic safety. Adverse weather generally refers to weather events such as rain, snow, fog, strong winds, and high temperatures with a certain intensity and impact range. The impact of adverse weather on vehicle driving is mainly reflected in the following aspects: firstly, under adverse weather condition, visibility decreases and the vehicle's perception ability of the driving environment decreases; The second is that adverse weather condition have an impact on road conditions, making it difficult for vehicles to operate and prone to rear end collisions and other traffic accidents.

Currently, there have been numerous studies on the impact of weather factors on driving behavior. However, existing research mainly focuses on specific driving behaviors in specific environments, making it difficult to find objective laws based on these research results. If these scattered and fragmented knowledge can be integrated to form a comprehensive and effective knowledge system, this knowledge can be applied to autonomous driving under complex weather condition. Knowledge graph, as a large-scale semantic network, can be used to describe concepts, entities, and their relationships in the objective world. The knowledge graph of driving behavior projects can integrate weather condition, environmental condition, and driving behavior into one knowledge graph, revealing the impact of weather and environmental condition on driving behavior, which is conducive to improving driving safety. This article constructs a knowledge graph of driving behavior projects, explores the constraint mechanisms of weather and environmental condition on driving behavior, and constructs a knowledge representation model to describe relevant knowledge. The innovation of this study lies in:

(1) A summary was made on the relationship between weather condition, environmental condition, and driving behavior, and an object representation model of "weather condition environmental condition driving behavior" was constructed to express the impact of weather factors on driving behavior.

(2) A representation method based on eigenvalues was proposed, which associates specific weather condition, environmental condition, and driving behavior. In the environmental condition, the relevant devices of autonomous vehicles are also included as part of the environmental condition. And based on existing laws, regulations, and relevant standards, construct a knowledge graph to achieve inference of driving behavior under specific weather and environmental condition.

The article is mainly divided into the following chapters: Chapter 2 mainly introduces the relevant progress; Chapter 3 proposes a method for constructing a knowledge graph of weather influencing driving behavior; Chapter 4 constructs a knowledge graph based on real-life knowledge to verify the practical value of this method; Chapter 5 summarizes the work of the article and provides prospects for future work.

2. Background

2.1. The Impact of Weather on Vehicle Driving

During the process of vehicle driving, weather factors have a constant and ubiquitous impact on driving. Existing research has summarized that weather factors mainly affect vehicle driving in the following two aspects: first, their impact on driving behavior, such as reducing vehicle speed, increasing distance between vehicles, and changing vehicle acceleration; Secondly, with the continuous application of autonomous driving technology, it has been found that weather factors have an impact on the perception of sensors in autonomous driving vehicles, leading to a decrease in camera imaging quality and a reduction in radar detection range (Heinzler et al., 2019).

Regarding the influence of weather on human driving behavior, Ni et al. (2022) research studied the impact of rainstorm weather on driving behavior, and believed that rainfall weather and ponding caused by rainfall weather would have a significant impact on driving behavior; Another study (Zang et al., 2019) suggests that under adverse weather condition, road friction will decrease as the intensity of adverse weather increases.

Autonomous vehicles are not only affected by human driving, but their sensors are also affected by weather factors. In complex weather condition, the sensors carried by autonomous vehicles are affected by weather condition. Complex weather condition can lead to difficulties in sensor recognition, misjudgment, and cognitive confusion (Heinzler et al., 2019). In addition, in some extreme cases, it can cause the sensors to directly fail to work; At the same time, existing environmental perception systems are unable to capture road surface information, which will affect the vehicle's judgment of the driving environment; some studies analyzed the impact of winter environment on autonomous vehicles and concluded that winter environment can have an impact on the perception system of autonomous vehicles, causing them to be unable to perceive the external environment and thus affecting their driving safety; Yoneda et al. (2019) analyzed the impact of adverse weather condition such as rain, snow, fog, and strong light on the installation of LiDAR, millimeter wave radar, cameras, and GPS systems in autonomous vehicles; Bijelic et al. (2020) explained the limitations of different sensors in heavy fog weather, and provided solutions for different sensor fusion; Zang et al. (2019) reviewed the impact of rain, snow, and fog on LiDAR, GPS systems, cameras, and radars, and described the impact of rainfall on vehicle radars. They concluded that under heavy rainfall (150 millimeters per hour), the detection range of millimeter wave radars can be reduced by 45%; Sakaridis et al. (2018) proposed a computer vision based processing method to address the impact of complex weather condition on vehicle sensors, which can detect and eliminate interferences, and restore image features.

Therefore, through reading and sorting out existing literature, the impact of weather factors on driving behavior can be summarized into three types: the impact of changes in visibility on driving behavior, the impact of changes in ground friction on driving behavior, and the impact on autonomous vehicle devices.

2.2. Introduction to Knowledge Graph and Related Applications

Knowledge graph is a special type of knowledge base (Tang et al., 2022), which differs from traditional knowledge bases in that it uses graphs to represent entities and relationships in the real world. Essentially, a knowledge graph is a semantic network that reveals relationships between entities. Generally speaking, the general representation of knowledge graphs is triplets, which mainly have two forms: $<$entity, relationship, entity$>$ and $<$entity, attribute, attribute value$>$.

According to different application fields, knowledge graphs can be divided into two categories: general knowledge graphs and domain knowledge graphs; The universal knowledge graph is oriented towards massive amounts of knowledge in the real world, emphasizing the comprehensiveness of concepts and entities; Domain knowledge graph is aimed at a specific domain, emphasizing the depth of the domain and the accuracy of knowledge, and can be applied to that domain. The construction of knowledge graphs can be done in a top-down or bottom-up manner. The top-down construction method is to first build the ontology and data patterns before constructing the knowledge graph, and then add knowledge to the knowledge base. The bottom-up construction method is to first extract entities from a large amount of data, filter them, add them to the database, and then build the ontology pattern (Tang et al., 2022).

In recent years, knowledge graphs for specific fields have been applied in multiple industries. Noueihed et al. (2022) constructed a weather event simulator based on the theoretical method of knowledge graph, which is used to replicate and measure weather events. Ayadi et al. (2022) proposed a knowledge graph based on open weather observation data, which formalizes the observed data and provides a large number of weather variables, thereby serving research in different fields. Wang et al. (2022) proposed a multilingual knowledge graph based on weather research and prediction models, which can provide effective query and analysis methods for the weather field and also help build knowledge bases in related fields.

Regarding the knowledge graph in the field of autonomous driving, Ma et al. (2021) constructed a knowledge graph based on the influence of other vehicles on drivers in reality, and combined it with surrounding vehicles to achieve reinforcement learning in autonomous navigation. Regarding the construction of driving scenarios in autonomous driving, relevant research has introduced knowledge graphs for overall representation, improving the efficiency of driving scenario representation (Wickramarachchi et al., 2021). Wickramarachchi et al. (2020). attempted to introduce the content of knowledge graphs to represent the large amount of data generated by autonomous vehicles, and evaluated the quality of knowledge graph construction. Schmid et al. (2019) explained the role of driving scene knowledge graphs based on generated scene knowledge graphs, and believed that scene knowledge graphs provide a unified semantic representation method for scenes, improving the ability to represent, integrate, and query autonomous driving. Elahi et al. (2020) used natural language processing techniques to extract relevant knowledge from natural texts about pedestrian and vehicle natural encounters, and constructed a knowledge graph to assist autonomous vehicles in making decisions.

In summary, knowledge graphs have been applied in fields such as autonomous driving and weather knowledge Q&A and analysis. However, there is relatively little research on knowledge graphs that combine weather factors and driving behavior. Therefore, how to store, organize, and express the knowledge that weather factors affect driving behavior, and apply it based on existing knowledge, is an important issue in related fields. Based on research, knowledge graphs can associate a large amount of weather data with driving behavior to assist autonomous vehicle driving.

3. Construction for Knowledge Graph of Driving Behavior under Adverse Weather

3.1. Knowledge Graph Construction Process

The top-down construction method is adopted for the knowledge graph of weather affected driving behavior, including knowledge model construction, knowledge acquisition and knowledge storage, as shown in Figure 1. Firstly, the influence mode of weather condition on environmental factors and driving behavior was analyzed, taking into account the relevant impact of weather on autonomous vehicles. On this basis, knowledge representation models at different layers are constructed. In addition, the corresponding entities and eigenvalues are extracted based on the standards of weather related fields and relevant laws and regulations. Finally, the graph database is used to organize and manage entities and eigenvalues, and the knowledge graph of weather affecting driving behavior is constructed.

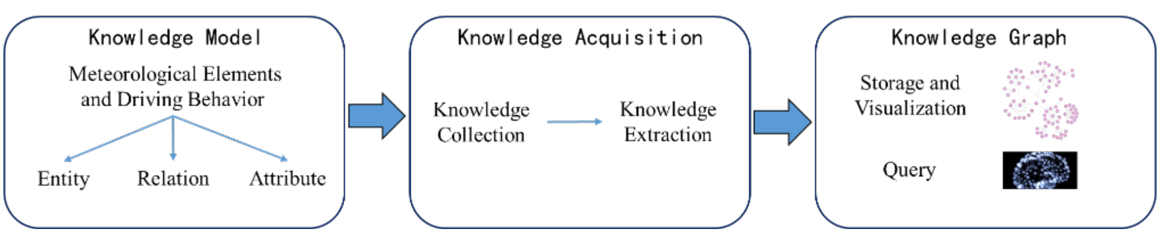

Figure 1: Construction process of knowledge graph of weather affected driving behavior.

3.2. Knowledge Model

The knowledge model is an abstract expression of the relationship between entities in reality, which represents the relationship between things in reality. The knowledge model in this paper expresses the relationship between weather and the driving behavior of autonomous vehicles. The model mainly includes the weather condition layer, environmental condition layer and driving behavior layer; Using our knowledge model, we can display these three different types of entities and express the relationship between these three entities. Our knowledge model is shown in Figure 2.

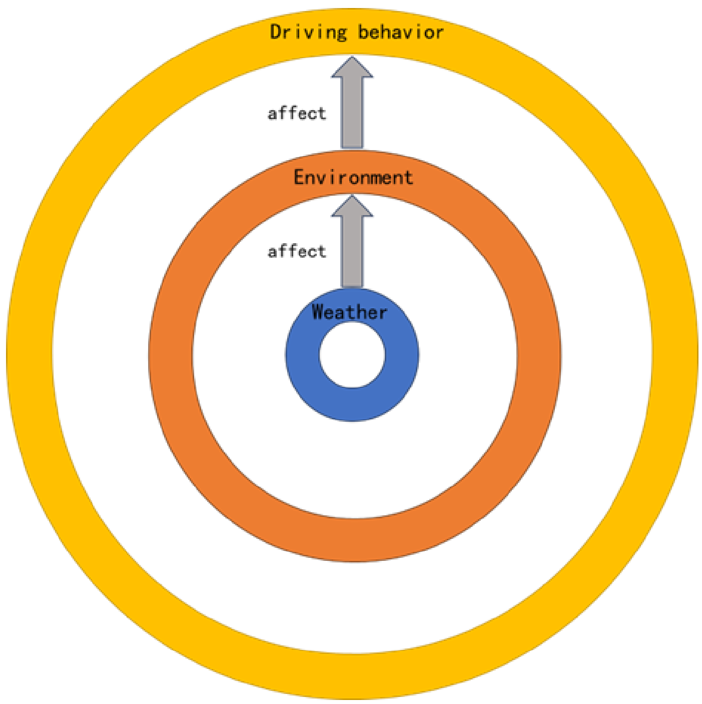

Figure 2: Relationship between different types of objects.

It can be found that weather condition affect driving behavior by affecting environmental condition. Changes in environmental condition can also affect driving behavior.

At the same time, as shown in Figure 3, the model defines three layers: object layer, attribute layer and relationship layer. The proposed model can describe the relationship between different types of objects.

Object Layer. The object layer includes three types of entities: the weather condition of the environment where the autonomous vehicle is located, the environmental condition of the autonomous vehicle and the driving behavior of the autonomous vehicle. In the following, these three types of objects are referred to as weather condition, environmental condition and driving behavior. Among them, the weather condition are sunny, rainy, snow, wind, fog and other weather condition; The environmental entity includes the environmental condition of the autonomous vehicle, such as friction, visibility and vehicle weight; Driving behavior refers to the driving behavior of autonomous vehicles during driving, including speed, steering, light control and other driving behaviors. The specific content of the object layer is shown in Figure 4.

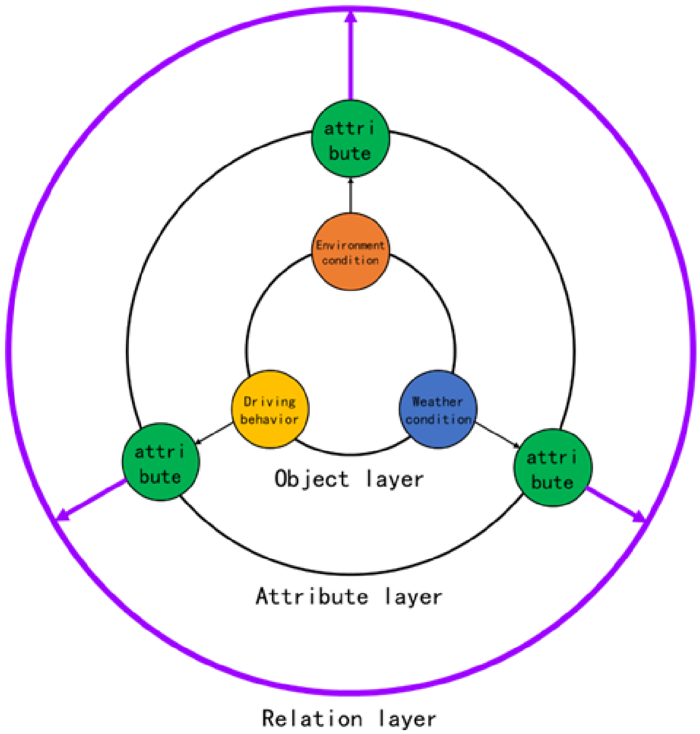

Figure 3: Knowledge graph representation model.

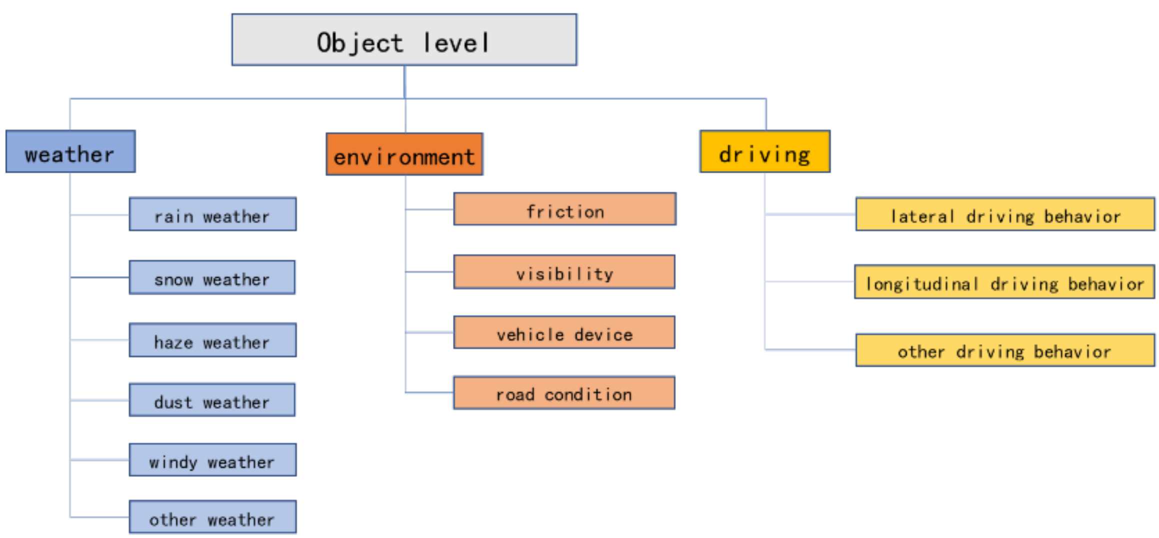

Figure 4: Object content of knowledge graph.

Table 1: Attribute layer of weather condition.

Object type	Object	Attribute
Weather condition	Rain weather	Valuefield, impact time, impact range
	Snow weather	Valuefield, impact time, impact range
	Hazy weather	Valuefield, impact time, impact range
	Windy weather	Valuefield, impact time, impact range
	Dust weather	Valuefield, impact time, impact range
	Other weather	Valuefield, impact time, impact range

Weather condition: weather is the part that affects the surrounding environment and driving behavior of autonomous vehicles; It has a direct or indirect impact on environmental condition and driving behavior. According to relevant weather standards, it can be divided into the following six categories: rainfall weather, snow weather, fog and haze weather, gale weather, sand and dust weather and other weather. For each type of weather, it can be further divided into several sub categories. For example, rainfall weather can be divided into light rain, moderate rain, heavy rain, rainstorm, heavy rainstorm and heavy rainstorm.

Environmental condition: environmental condition refer to the environmental factors involved in the driving process of the vehicle, which will have a direct impact on driving behavior. Environmental condition include friction, visibility, vehicle installations and road environment. The friction force mainly includes the magnitude, direction and coefficient of friction μ and slope; Visibility is divided into six categories from large to small according to relevant standards; The vehicle devices are divided into six categories according to the devices carried by the existing autonomous vehicles, such as laser radar and millimeter wave radar; The road environment is divided into expressway, ordinary highway.

Driving behavior: driving behavior involves the driving behavior of autonomous vehicles, which is affected by weather condition and environmental condition. Including speed, acceleration, steering, Lane merging, overtaking, avoidance, overtaking, vehicle lights, and driving behavior such as leaving the highway. Speed includes running speed and average speed; Steering is divided into left turn, right turn and U-turn; Merging is divided into left merging and right merging; Vehicle lights include low beam lights, high beam lights, steering lights, reversing lights, front fog lights, rear fog lights, clearance lights, license plate lights and brake lights.

Attribute Layer. The attribute layer refers to the features contained in the elements in the object layer; The attribute layer contains two types: attribute and action. Attributes represent the information of the elements in the object layer corresponding to the reality, including the definition of the object, the value range corresponding to the reality, and the time and space attributes of the object. For example, the value range corresponding to light rain weather is 0.1mm to 4.9mm for 12 hours or 0.1mm to 9.9mm for 24 hours. Actions represent specific actions that can be taken by driving behavior elements in the object layer. For example, the driving behavior of “right turn” includes two actions, “allow right turn” and “prohibit right turn”. The content of attribute layer is shown in Table 1 to Table 3:

Relation Layer. The relationship in the knowledge graph can be divided into three types. The first type is the relationship in the object layer, such as the relationship between instances and sub instances in the object layer, which is shown as “instance relationship sub instances”, such

Table 2: Attribute layer of weather condition.

Object type	Object	Attribute
Environment condition	Friction	Valuefield
	Visibility	Valuefield
	Vehicle device	Valuefield
	Road condition	Valuefield

Table 3: Attribute layer of driving behavior.

Object type	Object	Attribute
Driving behavior	Speed	Speed
	Acceleration	Accelerate, decelerate
	Turn	Allow turn, no turn
	Merge	Allow merge, no merge
	Overtake	Allow overtake, no overtake
	Avoid	Avoid
	Headway	Increase headway, decrease headway
	Leave highway	Leave highway
	Vehicle light	Turn on low beam
		Turn on high beam
		Turn on turn light
		Turn on backup light
		Turn on front fog light
		Turn on rear fog light
		Turn on position lights
	Whistle	Allow whistle, no whistle

as “rainfall weather - inclusion - light rain weather”. The second relationship is to connect the content in the object layer and the content in the attribute layer, which is shown as “instance/sub instance - relationship - value range/action”, such as “layer 5 wind - value range -8.0m/s 10.7m/s”. The third kind of relationship is the relationship in the attribute layer, which is shown as “value range relationship action”, such as “when the driving speed exceeds 100km/h - action - the distance between vehicles remains more than 100 meters”.

3.3. Knowledge Acquisition and Processing

Entity and Attribute Acquisition and Processing. The entities and attribute acquisition sources of weather affected driving behavior knowledge graph can be divided into the following three types, namely, weather condition entities and attributes, environmental condition entities and attributes, and driving behavior entities and attribute data. The sources of weather entities and attributes are mainly obtained from relevant national standards; One part of the entities and attributes of environmental condition can be obtained from relevant national standards, such as visibility and other entities and attributes, the other part needs to be obtained from relevant websites, and the entities and attributes of driving behavior can be obtained from relevant laws and regulations.

For weather condition, they are published in the form of quasi structured data when they are published, entities and their attributes can be obtained directly, and only the units need to be unified. For example, the units of wind speed include m/s, km/h, mi/h and knots, but we only use m/s as the unit of wind speed in this study. According to the environmental condition, we need to use the combination of manual extraction and machine extraction to extract the corresponding entities and attributes; For driving behavior, it is necessary to manually extract the provisions in relevant laws and regulations to extract the corresponding entities and attributes.

Relationship Acquisition and Processing. The relationships in the knowledge graph of weather influencing driving behavior can be divided into simple relationships and complex relationships. Simple relationships can be divided into three types: include relationship, valuefield relationship and action relationship. An example of a simple relationship is shown in the following Table 4.

Table 4: Examples of simple relationships in the knowledge graph.

Object	Relation	Object
Rain weather	Valuefield	Light rain
Vehicle device	Include	Lidar
Visibility	Valuefield	Visibility<50m
Light rain	Valuefield	24-hour cumulative precipitation of light rain:0.1mm-9.9mm
nighttime	Act	Turn on low beam
visibility<50m	Act	Driving speed not exceeding 30km/h

Among them, the inclusion relationship refers to the inclusion relationship between instances and sub instances. For example, the relationship between rainfall weather and light rain weather belongs to the inclusion relationship; The value range relationship refers to the relationship between the instance and the value range it contains. For example, the value range of rainfall weather is light rain weather; Attribute relationship refers to the attribute corresponding to the instance. For example, the value range of rainfall in light rain weather is 0.1mm to 4.9mm in 12 hours or 0.1mm to 9.9mm in 24 hours; The action relationship reflects the driving action taken by the vehicle. For example, when the visibility is less than 50 meters, the driving speed of the vehicle should not exceed 30 kilometers per hour, and the low beam lights should be turned on at night.

The compound relationship is the part of the knowledge graph of weather influencing driving behavior that cannot be directly expressed by simple relationships. As stipulated in Article 81 of the regulations for the implementation of the road traffic safety law of the people's Republic of China, when a motor vehicle is driving on an expressway, it shall comply with the following provisions in case of fog, rain, snow, sand dust, hail and other low visibility weather condition:

(1) When the visibility is less than 200 meters, turn on the fog lights, low beam lights, position lights and front and rear position lights. The vehicle speed shall not exceed 60 kilometers per hour, and keep a distance of more than 100 meters from the vehicle in front of the same lane;

(2) When the visibility is less than 100 meters, turn on the fog lights, low beam lights, position lights, front and rear position lights and hazard warning flashers. The vehicle speed shall not exceed 40 kilometers per hour, and keep a distance of more than 50 meters from the vehicle in front of the same lane;

(3) When the visibility is less than 50 meters, turn on the fog lights, low beam lights, position lights, front and rear position lights and hazard warning flashers. The vehicle speed shall not exceed 20 kilometers per hour, and drive away from the highway as soon as possible from the nearest exit.

Since each article of this provision contains multiple relationship conditions at the same time, it is necessary to use multiple simple relationships to form a composite relationship to express this provision, such as the content of Article 81 (2), which is shown in Figure 5.

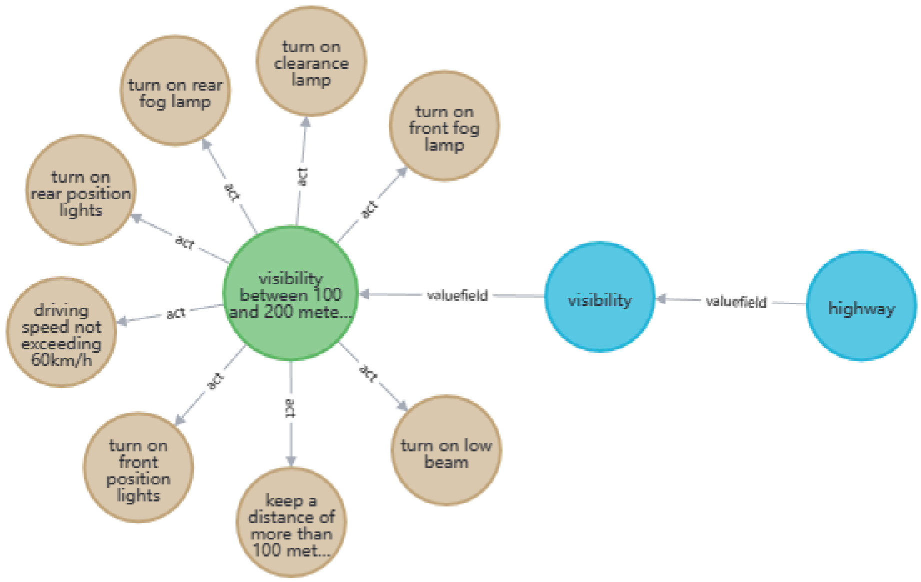

Figure 5: Composite relationship representation.

3.4. Knowledge Storage

The rich weather condition and driving behavior data contain a large number of attributes and relationships. The graphic database can effectively represent these data. In the graph database, instances, attributes, and value fields are stored as nodes, and semantic relationships are stored as edges.

The following figure shows the data storage of the knowledge graph of weather affecting driving behavior. With this diagram, various nodes can be used to store entities, attributes, actions, etc. Different colors represent different types and layers of entities, and different edges represent the hierarchy and characteristics of different objects.

Specifically, “weather condition” (blue) is the representative of weather condition objects. It contains various instances, such as rainfall weather, snowfall weather, fog and haze weather (light blue). Under the instance, it is the sub instance (light blue) contained in the instance. The sub instance represents the types contained in the instance, such as light snow, moderate snow, heavy snow, and heavy snow. “Environmental condition” (Orange) is the representative of environmental condition objects. It also contains various instances, such as friction, visibility and vehicle devices. Sub instances include the contents contained under the instances. Yellow represents the “driving entity”, which is the representative of the driving behavior object. The light yellow category corresponds to the driving behavior instance, such as speed, steering, etc. under the light yellow instance,

Table 5: Number of entities and relationships in the knowledge graph.

Object type	Num	Relation type	Num
Weather condition	47	Include relationship	125
Environment condition	41	valuefield relationship	99
Driving behavior	40	act relationship	79
Valuefield	76		
Act	42		

there are also light yellow sub instances, which correspond to the light yellow instance, representing that the lower face of the instance can also be subdivided into a series of driving behaviors.

Green nodes include value fields and actions, corresponding to the attribute layer in the knowledge model. The value domain node corresponds to the value domain of the instance and sub instances. For example, the snowy sub instance corresponds to the corresponding value of snowfall; The action node is a unique node contained in the driving behavior class object. Take the "right turn" sub instance as an example. The actions of this instance include two types: allow right turn and prohibit right turn. The above instances of different categories are represented by triples.

4. Case Study

4.1. Data

The data sources of this study mainly include the following two aspects: weather element data mainly comes from relevant national standards in the field, such as weather classification sourced from GB/T 22164-2017, rainfall and snowfall weather classification and corresponding precipitation layers sourced from GB/T 28592-2012, fog layer and corresponding visibility sourced from GB/T 27964-2011, relevant driving behavior sourced from the Implementation Regulations of the Road Traffic Safety Law of the People's Republic of China, and relevant environmental elements sourced from environmental factors involved in relevant research and laws and regulations.

After obtaining relevant knowledge, the first step is to process it according to the methods of constructing the knowledge graph in Chapter 3, and then classify it into weather condition, environmental condition, and driving behavior according to different categories of knowledge. And extract information such as attributes, value ranges, and actions of the object to obtain a triplet of the knowledge graph of weather impact driving behavior.

Use the Neo4j graphical database as a visualization tool for knowledge graphs to display the generated knowledge graphs. In this knowledge graph, there are 47 weather condition elements, 41 environmental condition elements, 40 driving behavior elements, as well as 76 value domain elements and 42 action elements; There are also 303 relationships, as shown in the Table 5:

4.2. Result Analysis

Querying event information is one of the main functions of knowledge graph. In this study, the following two types of tests were designed:

(1) Query other elements associated with an element; (2) Inquire about the driving behavior that the vehicle should take under specific weather or environmental condition.

Table 6: Different types of questions.

Question type	Question example	Cypher query language
Single element	What driving behavior should the vehicle take under the conditions of snow and muddy roads?	match (n{title:' Icy and muddy roads '})-[r]-(m:'act') return m,r,n
Multiple elements	If the visibility is less than 100 meters and the vehicle is driving on the highway, what driving behavior should the vehicle take?	match (n{title:'highway'})-[r:` condition `]->(m{title:' Visibility between 50 and 100 meters '})-[r1:`act`]->(q:``) return n,m,q,r,r1

For the first type of test, it is mainly to query the nodes and relationships related to an action. Query the node "turn on low beam" in neo4j, and you can see the adjacent nodes as shown in Figure 6.

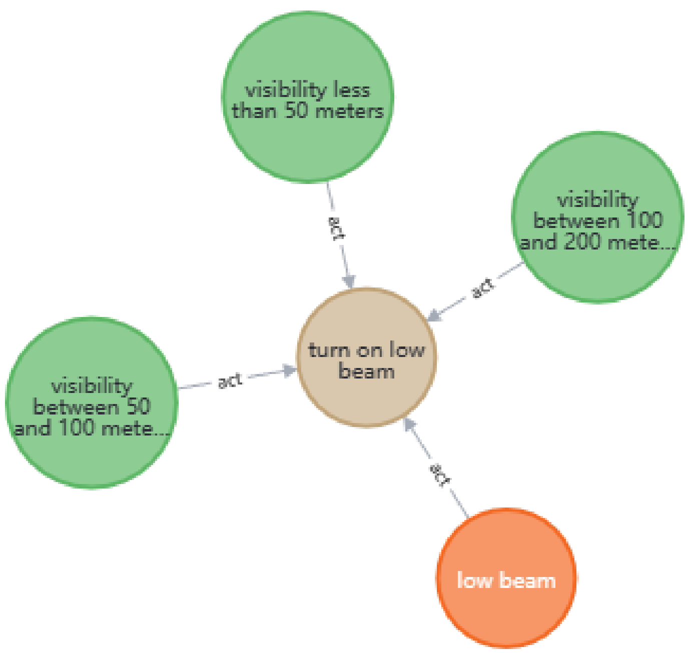

Figure 6: Query results of "turn on low beam" node.

For the second type of test, this experiment designed two questions for reasoning: (1) the influence of a single weather condition on the driving behavior of autonomous vehicles; (2) The influence of multiple weather and environmental condition on the driving behavior of autonomous vehicles; Table 6 lists the corresponding cypher query mode:

For the first question, the test was conducted in neo4j. The results showed that when the vehicle was driving on snow and muddy roads, the vehicle speed should not exceed 30km/h. The query results are shown in Figure 7.

For the second question, we tested the driving behavior that should be taken in visibility and highway scenes in neo4j, as shown in Figure 8; When the driving scene is Expressway and the

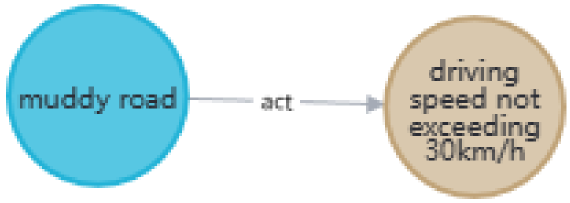

Figure 7: Single element query results.

visibility is less than 100 meters, the vehicle should keep a distance of more than 50 meters from the vehicle in front, and the vehicle speed should not exceed 40km/h. The low beam lights, front and rear fog lights, position lights and front and rear position lights should also be turned on.

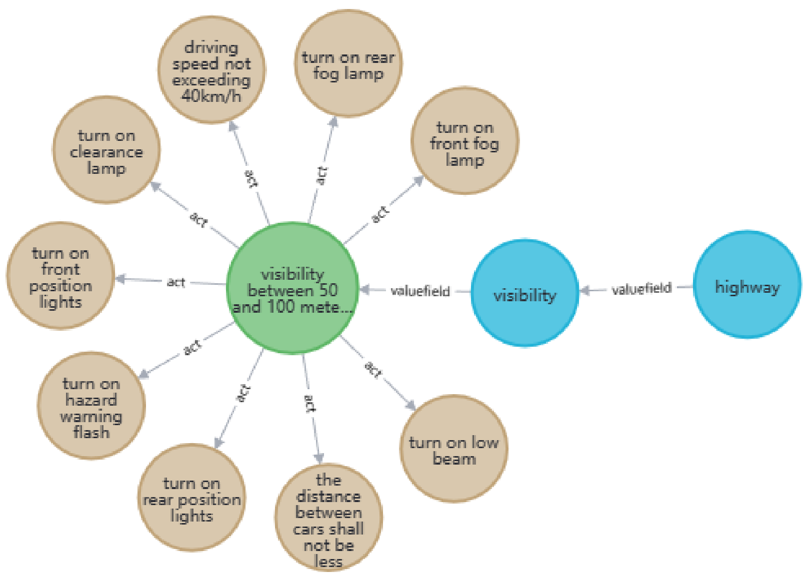

Figure 8: Multi element problem query results.

5. Discussion and Conclusion

5.1. Discussion

The knowledge graph of weather influencing driving behavior is composed of driving behavior, weather condition and environmental condition. The knowledge representation model proposed in this paper is the basis for constructing the knowledge graph of weather affected driving behavior. On the basis of analyzing the source of driving behavior, a knowledge representation model of weather influencing driving behavior is constructed from three layers: object, feature and relationship. The model takes into account the characteristics and action path of driving behavior affected by weather, and can describe different types of entities and relationships in the knowledge graph.

Driving behavior is closely related to weather condition. On the one hand, the change of weather condition will have an impact on the environment around the vehicle, such as the reduction of road friction coefficient and environmental visibility, which will further affect the driving of the vehicle; Therefore, this paper proposes a knowledge model of “weather condition - environmental condition - driving behavior” to express the influence process of weather condition on driving behavior. On the other hand, different weather condition also have different effects on driving behavior, such as the intensity of rainfall and snow is different, and the degree of influence on driving behavior is also different; This paper presents a method to express the relationship between eigenvalues and action values, which can express the different driving behaviors under different weather condition. Through the model proposed in this paper, the relationship between weather condition and driving behavior can be introduced into the knowledge graph, which can be used for behavior reasoning and control decision-making in the driving process.

In the process of automatic driving, we can identify the impact of different weather condition on driving behavior based on the weather and environmental information obtained by the automatic driving vehicle and match it with the knowledge graph, and then infer the driving behavior that the vehicle may need to take. For example, when rainfall suddenly occurs, it is considered that the vehicle should slow down.

However, the existing knowledge about driving behavior is based on human driving vehicles. With the continuous popularization of autonomous driving technology, the existing knowledge may not meet the needs of autonomous vehicles. Because there are certain differences between human driving and machine driving, for example, the reaction speed of machine is much faster than that of human, so the corresponding driving behavior will also be different. Although there are some differences in driving behavior, the constraints of weather condition on driving are realistic. Therefore, the related research still has great potential.

5.2. Conclusion

Knowledge graph is playing an increasingly important role in autonomous driving. Knowledge graph based on driving behavior can provide support for autonomous vehicle control decision-making, while weather condition are closely related to driving behavior. According to the relationship between weather condition and driving behavior, this paper proposes a method to construct the knowledge graph of weather condition affecting driving behavior. On the one hand, the relationship model of “weather condition - environmental condition - driving behavior” is constructed, which highlights the relationship between different types of objects in the knowledge graph. On the other hand, the knowledge representation model based on eigenvalues and actions is constructed to associate the specific weather condition with environmental condition and driving behavior. Based on the existing national standards in the field of Meteorology and road traffic safety regulations, the knowledge graph of weather affecting driving behavior is constructed, which can infer the driving behavior under specific weather condition and environmental condition. The results show that the constructed knowledge graph can fully express the impact of weather condition on driving behavior, and infer the related impact. On this basis, it provides support for the risk prediction and decision-making control of driving behavior under complex weather and environmental condition in the future. In addition, in future research, other factors affecting driving behavior can be further expanded and integrated into the knowledge representation model.

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