State Key Laboratory of Intelligent Coal Mining and Strata Control

Application Guide for 2025 Open Fund Projects

According to the "open, mobile, joint, and competitive" operating mechanism of the State Key Laboratory of Coal Intelligent Mining and Stratum Control, in order to create good scientific research conditions and academic atmosphere, attract and gather outstanding scholars at home and abroad to conduct joint research and joint research, promote high-level results, and build a scientific research activity base and talent training base in the field of coal intelligent mining and stratum control. In accordance with relevant regulations, the 2025 Open Fund Project Application Guide of the State Key Laboratory of Coal Intelligent Mining and Stratum Control is now publicly released.

I. Guidance Direction

Direction 1. Research and development of precise mining stress measurement technology and equipment (key project)

Research content:
Develop precise mining stress measurement technology and equipment to solve the applicability and accuracy problems of traditional measurement methods and provide efficient and accurate mining stress assessment tools for related engineering fields. Research content: (1) Optimization and integration of precise mining stress measurement methods; (2) Research and development of continuous, real-time and precise mining stress measurement equipment; (3) Construction of mining stress measurement data processing and evaluation platform.

Assessment indicators:
(1) Propose at least one new precise mining stress measurement method;
(2) Develop a set of precise mining stress measurement equipment;
(3) Develop a set of intelligent mining stress monitoring system;
(4) Publish 2 SCI papers.

Technical contact: Mr. Lou

Direction 2. Visual depth calculation in light-degraded scenes (general project)

Research content:
Study the theory and methods of visual depth calculation in light-degraded scenes, focus on

the visual depth calculation model in light-degraded scenes, explore the influence of different light-degraded conditions on visual depth calculation, and design the visual depth optimization method in light-degraded scenes; study the depth calculation method of multiple visual sensor fusion in light-degraded scenes, and break through the difficulty of high-quality depth acquisition in light-degraded scenes.

Assessment indicators:
(1) Design visual depth calculation model and optimization method in light-degraded scenes;
(2) Develop visual depth calculation software in light-degraded scenes;
(3) Prepare a standard draft around the visual depth calculation technology and application in light-degraded scenes;
(4) Publish 2 high-quality SCI/EI papers and apply for 1 invention patent.

Technical contact: Mr. Fan

Direction 3. Visual deduction of underground space time-varying trends (general project)

Research content:
Study the theory and analysis methods of visual deduction of underground space time-varying trends, focus on the time-varying characteristics and characterization methods of different visual sensor images (including visible light, non-visible light or depth and other different modal images) of underground space scenes, and design a visual deduction model for mine tunnel time-varying trends; based on the visual deduction model, study the intelligent analysis and prediction method of tunnel wall deformation trend to support efficient and accurate monitoring of mine tunnel deformation degree.

Assessment indicators:
(1) Establish a visual deduction model for mine tunnel time-varying trends and form an intelligent analysis and prediction scheme for mine tunnel wall deformation trends;
(2) Develop intelligent analysis and prediction software for tunnel wall deformation trends;
(3) Prepare a draft standard around the visual intelligent analysis and prediction method and application of underground space time-varying trends;
(4) Publish 2 high-quality SCI/EI papers and apply for 1 invention patent.

Technical contact: Mr. Fan

Direction 4. Force-immersive teleoperation control method for underground operation robots based on isomorphic wearable devices (general project)

Research content:
Establish a high-precision real-time force-position mapping model for wearable isomorphic master/slave teleoperation, design force/position mapping and bilateral force/position coordinated teleoperation controllers, and improve the dexterous operation ability and safety of slave arms; study the anti-delay stable control method based on the established real-time force-position mapping model to ensure the transparency and stability of the teleoperation process and improve the immersion of force control operation of underground operation robots. Build typical underground application scenarios and conduct force-immersive teleoperation demonstration and verification.

Assessment indicators:
(1) Establish a set of robot master/slave high-precision real-time force-immersive control models and methods based on wearable isomorphic devices with force feedback capabilities, and compile a standard draft;
(2) Feedback force ≥ 25N, force control accuracy better than 10%;
(3) Publish at least 1 SCI paper (JCR Zone II and above) and apply for at least 1 invention patent.

Technical contact: Mr. Fu

Direction 5. Multi-view adaptive accurate size reconstruction and measurement of scraper chain under variable environmental disturbance (general project)

Research content:
Research on efficient image acquisition system based on multi-view visual sensing and pre-segmentation method of scraper chain body area in multi-imaging perspective acquisition process under variable environmental disturbance, and efficiently extract pixel-level areas associated with scraper chain; for the selected pixel-level areas, use theoretical and numerical models to adaptively search for corresponding refined/sub-pixel edges around existing pixel boundaries; for occlusion, missing, noise adhesion and other situations, robust prediction can be made based on contextual information, and three-dimensional reconstruction can be performed on key features of repair to achieve abnormal detection of key dimensions of scraper chain.

Assessment indicators:
(1) Integrate multidisciplinary research methods such as artificial intelligence, pattern recognition, visual inspection and measurement, form a data acquisition hardware platform based on multi-eye visual perception and a precise measurement system for key dimensions of multiple scraper chains under variable environmental disturbances, and compile a draft standard;
(2) The error of key measurement dimensions of scraper chains is ≤ 2mm; (3) Apply for 1

invention patent and publish 1 SCI paper.

Technical contact: Mr. Zhang

Direction 6. Equipment life cycle network identification card (general project)

Research content:
Establish a coal mine equipment life cycle indicator evaluation system, build a multi-level and multi-stage evaluation model for key equipment components, study the management theory of the equipment life cycle, and form a full life cycle management standard; in view of the problems of difficulty in collecting real-time data, lack of data dimensions, and weak physical-information data interaction in the life cycle of mine equipment, design an integrated equipment life cycle monitoring terminal to realize heterogeneous multi-source and multi-modal data collection and fusion processing; establish an equipment life cycle management cloud service platform that supports information-physical fusion, summarize and analyze the collected equipment traceability data, establish an efficient mapping relationship between equipment traceability data and network identification cards, and realize rapid data association and query.

Assessment indicators:
(1) Develop a set of mine equipment life cycle monitoring data collection terminals;
(2) Prepare a draft of a coal mine equipment life cycle management standard;
(3) Develop an equipment life cycle data management software platform;
(4) Apply for an invention patent;
(5) Publish an SCI paper.

Technical contact: Mr. Tian

Direction 7. Digital representation of end surface characteristics and its influence and application on rock failure (general project)

Research content:
Establish multi-dimensional quantitative characterization indicators of sample end surface characteristics, and form a digital representation method for sample end surface characteristics; on this basis, establish a physical model and numerical model of rock material failure under complex stress paths, and obtain the evolution law of end surface characteristics on the "time-space-strength" failure signal of rock; by combining with indoor rock mechanics tests, reveal the influence of end surface characteristics on the failure process of rock materials; based on typical geological conditions, combine physical and numerical models to analyze and predict the influence of roof and floor fluctuations on the stress distribution of coal seams in mining, and provide a basis for the formulation of advanced prevention and

control strategies for dynamic disasters.

Assessment indicators:
(1) Construct a digital characterization method for the end surface characteristics of the specimen;
(2) Reveal the influence of the end surface characteristics on the failure process of rock materials;
(3) Clarify the influence of the roof and floor fluctuations on the stress distribution of coal seams during mining;
(4) Publish 2 SCI papers (JCR1 zone);
(5) Prepare a draft standard for testing the impact tendency of coal and rock masses, a draft standard for measuring the end surface flatness of rock mechanics test samples, or a draft standard for digital description of the end surface flatness of rock samples.

Technical contact: Mr. Shi

Direction 8. Intelligent prediction system for hidden geological factors causing disasters in coal mines based on large models (general project)

Research content:
(1) Construction of multi-source heterogeneous data knowledge base: Based on knowledge graph and RAG (Retrieval-Augmented Generation) technology, a knowledge base and database of hidden geological factors causing disasters in coal mines are constructed to realize the integration and intelligent management of hidden geological body information and data. The knowledge base will contain multimodal data of geological bodies, such as text, images, sensor data, etc., as well as relevant professional knowledge and historical cases to support the development and operation of intelligent prediction systems;
(2) Intelligent agent development platform prototype system: Develop a low-code platform prototype system specifically for the development of AI intelligent agents for hidden geological factors causing disasters. The platform will integrate functions such as intelligent agent development and release, workflow orchestration, plug-in development and management, knowledge base creation and management, memory settings, dialogue experience, and role settings to realize intelligent prediction and early warning of hidden geological factors causing disasters. The platform will support the rapid development and deployment of AI applications, improve the system's response speed and prediction accuracy;
(3) Intelligent prediction and forecasting technology: Using AI intelligent agent technology, combined with historical knowledge and domain professional models, autonomously analyze the generation mechanism and generation mechanism of geological disaster bodies, and realize the prediction and forecast of hidden disaster-causing geological factors. Through deep learning and machine learning technology, improve the accuracy and efficiency of prediction, and provide a scientific basis for coal mine safety production.

Assessment indicators:
(1) Knowledge base construction: Build a knowledge base of coal mine hidden disaster geological factors, including common coal mine hidden disaster geological body multimodal data, to ensure the comprehensiveness and accuracy of the knowledge base;
(2) Intelligent prediction and forecasting capabilities: Establish a large model of coal mine hidden disaster geological factors, which can realize the intelligent prediction and forecast of hidden disaster geological factors, and improve the accuracy and response speed of the forecast;
(3) Forecast accuracy: The forecast accuracy reaches more than 80%;
(4) Academic achievements and intellectual property rights: 1 SCI paper accepted, 1 invention patent accepted.

Technical contact: Mr. Chen

Direction 9 Intelligent identification and interpretation method of geological anomalies in mines based on deep learning (general project)

Research content:
In view of the high time cost and low degree of automation in the interpretation of geological anomalies such as collapse columns, faults and goafs in coal mine seismic exploration data, a high-precision and efficient intelligent identification and interpretation method based on deep learning is studied. Specific content: (1) For at least one type of geological anomaly, a data set with anomaly labels is constructed through model forward modeling or artificial data synthesis; (2) Data augmentation or data synthesis methods based on generative modeling technology are studied to expand the scale of data sets used for deep learning model training; (3) A high-precision and efficient intelligent identification model and algorithm for geological anomalies based on deep learning is proposed; (4) Based on the anomaly recognition results of the algorithm, an automatic interpretation technology for the automatic interpretation of the anomaly surface is studied and proposed.

Assessment indicators:
(1) Propose an intelligent recognition and interpretation model based on deep learning for at least one type of geological anomaly, and exceed the manual interpretation results on the actual work area data;
(2) Accept one invention patent;
(3) Accept one SCI/EI indexed journal paper.

Technical contact: Mr. Liu

Direction 10. Research on robot inertial navigation/vision combined

navigation and path planning in unstructured underground environment (general project)

Research content:
Analyze the influence mechanism of complex environmental factors such as low illumination, high dust, rugged terrain, strong magnetic field interference, and narrow space on the performance parameters of inertial navigation/vision sensors, establish a sensor error model for visual-spatial-magnetic coupling in unstructured environment, further study the robot real-time positioning and attitude estimation algorithm under multi-source information error model, and explore the inertial navigation/vision combined navigation method for harsh underground conditions; combine underground environmental information (such as obstacle distribution, tunnel direction, geological conditions, etc.) and robot kinematic constraints (such as size restrictions, minimum turning radius, etc.) to analyze the internal and external action mechanism of the motion path, and construct a strong robust path planning algorithm; conduct experiments and algorithm optimization in combination with actual underground scenes, further verify, compare and calibrate the theoretical and experimental models, and develop robot autonomous intelligent navigation and path planning strategies that meet the reliability, stability and accuracy requirements of underground unstructured environments.

Assessment indicators:
(1) Establish a sensor error model for visual-spatial-magnetic coupling in an unstructured underground environment;
(2) Construct an inertial navigation/visual combined navigation strategy for harsh underground conditions;
(3) Complete the design of a robust path planning algorithm under the internal and external effects of an unstructured underground environment and robot motion constraints;
(4) Publish 1-2 SCI journal papers.

Technical contact: Mr. Ren

Direction 11. Nonlinear degradation mechanism and life prediction of pick performance under high-speed cutting-impact load conditions (general project)

Research content:
Coal mining equipment picks are in service under high-speed cutting-impact load conditions for a long time, crushing and cutting coal seams under extremely strong thrust. The high temperature generated by the high-impact and high-stress service state causes the pick tooth body to wear and fracture, and the tooth tip to wear and fracture with great nonlinearity. The surface mechanical properties of the pick under high temperature conditions and the bonding strength between the tooth tip and the tooth seat base have greater uncertainty. Based on this,

the soft failure caused by high-speed cutting wear degradation and the hard failure caused by random load impact increase the uncertainty of the life prediction of the pick. By considering the effects of continuous impact, variable rate accelerated degradation and hard failure threshold change on pick wear, it is of great significance to study the nonlinear degradation mechanism and life prediction of pick performance under high-speed cutting-impact load conditions. The project content includes: (1) Study the high-temperature friction and wear mechanism and high-temperature toughness mechanism of picks under high-speed cutting-impact load conditions, explore the bonding strength of brazing between the tooth tip and the tooth body under high temperature, and analyze the failure form and failure mechanism of picks; (2) According to the failure form of the pick, based on natural wear degradation, impact instantaneous degradation and variable rate accelerated degradation during the impact duration, study the nonlinear degradation mechanism of pick performance under high-speed cutting-impact loads; (3) Carry out the prediction of pick fatigue life based on BP neural network, and obtain the correlation between the fatigue life of the pick and the total deformation, equivalent stress and equivalent elastic strain of the pick.

Assessment indicators:
(1) Combined with high-temperature mechanical performance experiments, reveal the high-temperature friction and wear mechanism of picks under high-speed cutting-impact load conditions, and construct a mechanical model of pick failure;
(2) Through the analysis of pick cutting failure, reveal the nonlinear degradation mechanism of pick performance under high-speed cutting-impact load conditions;
(3) Based on finite element analysis, establish a pick life prediction model based on BP neural network;
(4) Publish 2 SCI papers (JCR Zone 1).

Technical contact: Mr. Ren

Direction 12. Research on key technologies of intelligent diagnosis and life prediction of tunneling equipment driven by mechanism-knowledge-data hybrid (general project)

Research content:
There is little fault data of tunneling equipment, many fault modes, and strong fault correlation. The method based on data drive alone is overly dependent on training data, lacks the necessary mechanism and experience guidance, and has poor generalization ability and interpretability. Therefore, how to combine the structural characteristics and failure mechanism of tunneling equipment, integrate the mechanism model, knowledge model and data-driven model, and study the self-analysis of fault trends, self-forecast of fault types and self-prediction of remaining life under multiple components, multiple degradation mechanisms and multiple fault types, so as to provide a scientific basis for self-decision-making of operation and maintenance plans and self-optimization of inventory

resources, so as to seek more efficient, economical and scientific intelligent operation and maintenance methods, which is of great significance for improving the safe and reliable operation capability of tunneling equipment and realizing the "transformation from manufacturing to manufacturing services" of coal machinery equipment enterprises. The specific research contents are: (1) Research on fault diagnosis of tunneling equipment based on multi-source, multi-dimensional and heterogeneous data fusion; (2) Research on multi-mode fault diagnosis of tunneling equipment guided by mechanism-knowledge; (3) Research on life prediction of tunneling equipment based on multi-scale information deep migration; (4) Research on predictive maintenance and resource optimization of tunneling equipment based on diagnosis-prediction information collaboration.

Assessment indicators:
(1) The system has no less than 30 access measurement points, covering core subsystems such as transmission system, electrical system, hydraulic system, etc., including multi-source, multi-dimensional, heterogeneous indicators such as vibration, oil, temperature, current, voltage, etc.;
(2) Construct a mapping network between the indicator tree and the fault tree;
(3) Achieve accurate fault diagnosis and reliable life prediction, with no less than 20 types of faults and no less than 10 algorithm models;
(4) Fault identification accuracy > 80%, life prediction accuracy > 60%;
(5) Publish 2 SCI papers (JCR Zone 2 or above);
(6) Apply for 2 invention patents.

Technical contact: Mr. Qin

Direction 13. Design and performance optimization of bionic wear-resistant structure of cutting tooth seat of mining equipment (general project)

Research content:
Through bionic coupling technology, the material properties, structural parameters and contour morphology of biological prototypes are deeply analyzed, and a bionic tooth seat structure with synergistic effect is designed to achieve synergistic improvement of drag reduction, wear resistance and thermal stability performance in high-intensity cutting conditions. By studying the interaction between tooth seat and coal rock, the tooth seat-coal rock action mechanism is proposed. Under the coupling of thermal-solid multi-physical fields, the stress field and temperature distribution on the tooth seat surface are analyzed, and a prediction model for the tooth seat life under force and thermal coupling is established. The structural parameters of the bionic tooth seat are optimized by response surface method or orthogonal test method to determine the optimal bionic structure. In order to further improve the wear resistance of the bionic tooth seat, surface strengthening technologies such as surface alloying, cladding and coating are studied to optimize the performance of the bionic structure

and obtain the surface strengthening technology of the high-performance wear-resistant layer suitable for the bionic tooth seat. The wear resistance of the bionic tooth seat structure is verified by experiments.

Assessment indicators:
(1) Design a bionic high wear-resistant and drag-reducing mining equipment tooth seat structure;
(2) Construct a tooth seat life prediction model under the coupling of force and thermal field;
(3) Complete the optimization of the bionic tooth seat structure based on the experimental optimization method and obtain the optimal structural parameters;
(4) Prepare the tooth seat bionic surface wear-resistant layer structure;
(5) Publish 2 SCI papers (JCR Zone 2);
(6) The bionic tooth seat reduces the wear of the original tooth seat by about 15%-20%.

Technical contact: Mr. Wang

Direction 14. Research on dynamic model and calculation method of belt conveyor (general project)

Research content:
Propose the viscoelastic mechanics theory of conveyor belt, establish the viscoelastic model of conveyor belt, and further study the dynamic characteristics of conveyor belt. There are many types of conveyor belts with different structures, but all of them have obvious viscoelastic properties. According to the characteristics of different types of conveyor belts, considering the influence of factors such as temperature and speed, the viscoelastic models of various types of conveyor belts are studied and established; a database of viscoelastic parameters (elastic modulus, damping coefficient) of conveyor belts is established; the conveyor belts are divided into units, and the force analysis is performed using viscoelastic dynamics. The force balance equations of multiple units are established, and the numerical analysis method is used to solve them, and then the dynamic model of the whole machine is established to provide theoretical support for the design of conveyor belts and the operation control in complex environments.

Assessment indicators:
(1) Establish viscoelastic models of various types of conveyor belts;
(2) Establish a database of viscoelastic parameters (elastic modulus, damping coefficient) of conveyor belts;
(3) Establish a dynamic model of the whole belt conveyor;
(4) Through the effective combination of multiple research methods (theoretical and numerical models, indoor experiments, on-site monitoring, etc.) and the full-scale intersection of multiple disciplines (elastic mechanics, material mechanics, mechanical dynamics, etc.), an integrated research framework is achieved;
(5) Publish 2 SCI papers.

Technical contact: Mr. Song

Direction 15. Research on the failure sensing technology of dumbbell pins in scraper conveying equipment (general project)

Research content:
In view of the various problems of dumbbell pins being lost or broken during the use of scraper conveying equipment, the state of dumbbell pins can be sensed and fault alarm can be realized by studying the technologies of dumbbell pin failure recognition, signal transmission, and processing. Specifically, it includes: (1) Research on the failure recognition technology of dumbbell pins on both sides of the middle groove; (2) Design of power supply and signal transmission of dumbbell pin failure sensing system; (3) Research on the integrated application of dumbbell pin failure sensing and working condition monitoring system.

Assessment indicators:
(1) Complete one set of dumbbell pin failure sensing system;
(2) The accuracy of sensing failures such as dumbbell pin loss and breakage is ≥95%;
(3) ≥2 authorized invention patents;
(4) Publish 2 EI papers.

Technical contact: Mr. Li

Direction 16. Research on self-navigation position detection technology for the tail of a self-moving belt machine for chute (general project)

Research content:
The relative position of the tail of a self-moving belt machine and the amount of belt deviation cannot be accurately measured, resulting in the need for human intervention during the equipment movement process, and the inability to achieve self-navigation and unmanned operation of the equipment. This project mainly studies a belt deviation and position detection technology suitable for underground coal mines, including: (1) Research on the position detection method of the tail of a self-moving belt machine in the complex environment of coal mines; (2) Research on the real-time detection algorithm of belt deviation; (3) Research on the position detection algorithm of the tail of a self-moving belt machine relative to the belt frame.

Assessment indicators:
(1) 1 set of algorithms for position detection and belt deviation of the tail of a self-moving belt machine for chute;

(2) Effective measurement distance ≥10m;
(3) Position detection error ≤50mm, deviation detection error ≤20mm;
(4) ≥1 authorized invention patent; ≥2 software copyrights;
(5) Published 2 EI papers.

Technical contact: Mr. Li

Direction 17. Research on the method of accurate moving target recognition of millimeter-wave radar in complex underground environment (general project)

Research content:
In the narrow and long tunnel environment of coal mines, affected by scene clutter interference and multipath effect, the interference distribution of millimeter-wave radar is random, the process is complex, and overlaps with target features, which leads to a decrease in target recognition accuracy. The existing technical methods have insufficient performance in suppressing multipath transmission interference of radar transmission signals, making it difficult to extract weak targets such as mobile workers from strong interference and suppress false targets. How to effectively use the reflected signal of millimeter-wave radar to accurately detect weak targets in complex underground environments is the research focus of this project. The main research contents include: (1) The transmission and interference model of millimeter-wave radar target echo signal in the narrow and long tunnel environment of underground mines; (2) Research on the separation strategy of multi-target echo signals of underground millimeter-wave radar to suppress false targets and enhance and detect weak target signals; (3) Research on multi-target detection and tracking methods fused with millimeter-wave radar and camera to achieve accurate real-time recognition of moving targets such as workers in complex underground coal mine environments.

Assessment indicators:
(1) Realize the enhancement and detection of moving target signals such as workers in underground tunnel environments by millimeter-wave radar, with a detection accuracy of ≥95%;
(2) Study the feature-level fusion target detection algorithm of millimeter-wave radar and high-speed camera, and realize the recognition of moving targets in complex scenes such as low light, high dust, and water mist, with a false alarm rate of <3% and an accuracy of ≥97%;
(3) Publish 2 SCI/EI papers.

Technical contact: Mr. Ye

Direction 18. Research on high-reliability distributed communication technology for underground industrial control sites (general project)

Research content:
At present, the underground backbone network of coal mines has achieved Ethernet coverage, and each edge device can exchange data based on Ethernet. Common communication protocols include ModbusTCP, EIP, PROFINET, etc. However, the robustness, reliability, and real-time performance of communication between devices in industrial control scenarios cannot be guaranteed, and the inter-system coordination ability needs to be improved. Distributed communication technology needs to automatically build highly reliable and real-time communication channels for edge devices, with complete discovery connection, device networking, data and service publishing functions, one-to-one, one-to-many, multicast and other efficient communication methods, and high reliability, strong real-time and other industrial protocol characteristics. Distributed communication is the foundation and base for building distributed control systems. The main research contents include: (1) Distributed modeling language or standard. Research distributed modeling language and standards, and design distributed modeling solutions suitable for coal mine industrial sites; (2) Distributed communication theory and methods. Research on current mainstream distributed communication methods and link protocols, and design communication protocols based on the characteristics of underground link communication in coal mines. Special attention should be paid to the robustness, reliability, real-time, self-healing ability and other contents of communication; (3) Distributed network communication implementation. According to the modeling scheme and communication technology, complete the construction of distributed communication system.

Assessment indicators:
(1) A set of highly reliable and real-time distributed communication system modeling solutions (languages): ① with the functions of discovering connections, device networking, data and service publishing; ② supporting one-to-one, one-to-many, multicast and other communication methods; ③ distributed node capacity > 128;
(2) A set of distributed communication software (including source code): ① at least support ARM32 and ARM64; ② RAM usage ≤ 256MB, CPU usage ≤ 60%; ③ end-to-end data delay ≤ 10ms, jitter < 1ms (100M Ethernet, 20% load rate, ARM32 single-core 1G processor); ④ network self-healing time ≤ 50ms (100M Ethernet);
(3) Publish 2 SCI/EI papers.

Technical contact: Mr. Yuan

Direction 19. Research on real seismic full waveform data inversion imaging algorithm based on machine learning method (general project)

Research content:
Controllable impact source has broken through the technical bottleneck of traditional hammer source based on surface wave energy, and has developed into a new deep illumination,

ultra-wideband and high signal-to-noise ratio source technology. The new controllable impact geophysical exploration technology based on this source can provide real pulse seismic full reflection gather data with a depth of kilometers and a resolution of meters for seismic exploration projects, and also poses new challenges to the wave velocity structure inversion imaging algorithm. The specific research contents include: (1) Establishing a machine learning algorithm for the source pulse wavelet solution of the full waveform seismic gather of the controllable shock source, which can effectively extract the shock source pulse wavelet and perform cross-correlation noise reduction, energy and frequency band compensation based on it; (2) Taking the full waveform inversion method as the technical framework, based on the machine learning method, a gradient solution scheme and algorithm are proposed to replace the numerical method of the adjoint wave field gradient calculation; (3) Constructing a process-based machine learning algorithm based on the above wavelet solution and full waveform inversion to perform high-fitting full waveform inversion imaging of the shock source seismic gather.

Assessment indicators:

(1) Establishing a machine learning scheme for the source pulse wavelet solution of the full waveform seismic gather of the controllable shock source, which can effectively extract the shock source pulse wavelet and perform cross-correlation noise reduction, energy and frequency band compensation based on it;

(2) Constructing a wave velocity field iterative gradient solution algorithm based on the machine learning method to achieve effective convergence of the real pulse seismic full waveform gather, and the RMSE is less than 25% after the iteration is stable;

(3) Publish 2 SCI papers (above the 2nd zone of the Chinese Academy of Sciences).

Technical contact: Mr. Cui

Direction 20. Study on the adsorption-deformation coupling characteristics of rock nanopores under stress state (general project)

Research content:

The existence of nanopores will cause significant deformation and stress changes in the rock during the adsorption/desorption process, and further affect the long-term stability of the engineering rock mass. The microscopic mechanism of this coupling phenomenon is still unclear and the theoretical model is immature. Due to the extremely limited in-situ experimental means at the nanoscale, the coupling mechanism of adsorption-deformation in nanopores can be analyzed with the help of atomic simulation methods, and on this basis, the microscopic analysis results can be homogenized to the macroscale, so as to obtain the adsorption-deformation coupling theory under stress state, and cross-validate with macroscopic experiments. The main research contents include: (1) Study on the microscopic mechanism of rock adsorption-deformation coupling. Analyze the physical mechanism of nanopore adsorption-deformation coupling at the atomic scale and clarify the main role of external stress in this mechanism; (2) Construct a theoretical model of adsorption-deformation in nanopores. Combined with the microscopic mechanism, based on the multi-scale

mechanics framework, the atomic simulation results are homogenized upward to establish a theoretical model that quantitatively describes the adsorption-deformation relationship of rock nanopores; (3) Experimental verification of the adsorption-deformation theoretical model. Take brittle rocks to conduct water vapor adsorption tests at different stress levels, calibrate the relationship between deformation and adsorption, and compare it with the predicted results of the constructed theoretical model.

Assessment indicators:
(1) Give the microscopic mechanism of adsorption-deformation coupling in rock nanopores;
(2) Construct a theoretical model of nanopore adsorption-deformation under stress conditions;
(3) Clarify the relationship between rock water vapor adsorption-deformation coupling characteristics and external stress;
(4) Publish 2 SCI papers (JCR Zone 1).

Technical contact: Mr. Wu

Direction 21. High-precision monitoring of acoustic emission of rock fracture based on deep learning (general project)

Research content:
The latest research on indoor rock mechanics experiments shows that the acoustic emission signal of rock before fracture contains key information to reveal the subsequent fracture mechanism; as an important indicator signal reflecting the fracture state of rock or fault, acoustic emission has great application potential in predicting sudden damage in rock mechanics experiments and mining processes. Extended to the field monitoring scale, real-time and high-precision monitoring of mine earthquakes in actual mining processes is one of the key measures to control and mitigate the risk of mine earthquakes. In recent years, the application of deep learning technology in the field of seismic signal analysis has achieved remarkable results, and has achieved a breakthrough improvement in the accuracy, accuracy and efficiency of waveform picking compared with traditional methods. This study aims to develop a high-precision analysis algorithm for acoustic emission of rock fracture based on deep learning, so as to realize the fully automatic and high-precision detection and positioning of fracture signals in laboratory or field monitoring. Based on the self-similarity characteristics of earthquakes, explore the empirical scaling law applicable to indoor rock mechanics experiments and field mine earthquakes, and establish a technical path that can migrate the pre-trained model based on traditional seismic data to different application scales. By constructing a fully automatic positioning process for acoustic emission and mine earthquake signals, the feasibility and key conditions of real-time monitoring of rock fracture status based on high-precision acoustic emission monitoring are further explored, providing innovative technical support and scientific basis for mining safety monitoring and earthquake mechanism research.

Assessment indicators:

(1) Explore the empirical scaling law based on the pre-trained earthquake detection model, and construct a high-precision machine learning model suitable for rock mechanics acoustic emission signals and field mine earthquakes;
(2) Build a fully automatic, high-precision acoustic emission monitoring and positioning process to achieve continuous and efficient monitoring of indoor rock mechanics experiments;
(3) Publish 2 SCI papers (JCR Zone 1).

Technical contact: Mr. Wu

Direction 22. Study on the size effect of tunnel surrounding rock disturbance characteristics and support effect (general project)

Research content:
Explore the influence of cross-section size changes on the disturbance range and stress redistribution characteristics during tunnel excavation, and establish a disturbance influence range prediction model that simultaneously considers tunnel section size, original rock stress and coal rock mechanical parameters. Analyze the size effect characteristics of coal-rock structural surface in the coal side height direction and its mechanism of action on coal side failure mode, and reveal the working principle of anchor (cable) support in the stability control of coal side in super-high tunnels. Study the influence mechanism of factors such as direct roof lithology, direct roof thickness and basic roof thickness on the deformation and destruction of super-wide roof, clarify the process of anchor (cable) support on the stability of super-wide tunnel roof, and quantitatively analyze the influence of anchor (cable) arrangement mode and support parameters on the support effect.

Assessment indicators:
(1) Establish a size effect model of tunnel surrounding rock structure and stress characteristics;
(2) Construct a calculation equation for the influence range of tunnel excavation disturbance;
(3) Reveal the mechanism of tunnel size effect;
(4) Reveal the action characteristics of anchor (cable) support with tunnel size effect;
(5) Publish 2 SCI papers (JCR Zone 1).

Technical contact: Mr. Yang

Direction 23. Formation law and optimization control of artificial frozen wall in weakly cemented rock formations in western China under the action of high-velocity groundwater (general project)

Research content:

Using indoor test methods, obtain the thermal physical and mechanical parameters and microstructural characteristics of weakly cemented rock formations in western China; using a combination of model tests and theoretical analysis methods, study the evolution law of the freezing temperature field of weakly cemented rock formations in western China under the action of high-velocity groundwater, reveal the influence of factors such as groundwater velocity, rock fracture opening and angle on the artificial freezing temperature field, and derive the analytical solution of the freezing temperature field; using a combination of theoretical analysis and numerical calculation methods, construct a numerical calculation model of water-heat-force three-field coupling of weakly cemented low-temperature rock mass considering the random distribution of fractures, and combine actual engineering parameters to calculate and analyze the causes of poor development of artificial frozen wall under such rock formation conditions, and propose an optimization control method for the artificial freezing temperature field for such rock formations.

Assessment indicators:
(1) Obtain the freezability and microstructural characteristics of weakly cemented rock formations in the west;
(2) Reveal the water-heat-force three-field coupling mechanism of weakly cemented frozen rock formations in the west under the action of high-velocity groundwater;
(3) Derive the temporal and spatial evolution law of the freezing temperature field of weakly cemented rock formations in the west under the action of high-velocity groundwater;
(4) Propose an optimization control method for the freezing wall of vertical shafts in weakly cemented rock formations in the west under the action of high-velocity groundwater;
(5) Publish 4 SCI papers (JCR Zone 1);
(6) Apply for 1 invention patent.

Technical contact: Mr. Ding

Direction 24. Comprehensive mechanism analysis of frost heave development and control during the application of artificial freezing method (general project)

Research content:
Study the distribution and evolution of capillary water, film water and pore ice under low temperature conditions, and build a model of the occurrence and evolution of capillary-film water in the freezing edge zone in combination with the characteristics of soil pore structure; use capillary theory, film water theory and crystallization pressure theory, combined with the pressure-suction stress conversion relationship, to build a pressure-suction stress distribution model of capillary-film water in the freezing edge zone; according to the migration driving force analysis, determine the migration path and direction of capillary-film water, and reveal the migration law of water in the freezing edge zone. The tensile strength test of frozen soil was carried out to reveal the law of change of tensile strength of frozen soil with temperature;

on this basis, combined with the formation conditions of segregated ice, the formation mechanism model of segregated ice was constructed; according to the generalized Clapeyron and Gibbs-Thomson equations, the control mechanism of interface effect on the freezing temperature of liquid water at any interface was analyzed, and combined with the interface characteristics of segregated ice, the melting mechanism model of segregated ice was constructed; according to the above model analysis, the formation and melting temperature of segregated ice was determined, the freeze-thaw hysteresis temperature range of segregated ice was obtained, and the freeze-thaw hysteresis mechanism of segregated ice was revealed. According to the pressure-absorption stress distribution model of capillary-film water in the frozen edge zone, the law of change of migration driving force with temperature was determined, and the control temperature of zero migration driving force at the warm end of segregated ice was explored; according to the freeze-thaw hysteresis characteristics of segregated ice, the stop development zone of segregated ice was determined (the segregated ice neither grows and develops nor melts in this bandwidth); on this basis, combined with the water-insulating characteristics of segregated ice, the formation, development and control mechanism of segregated ice were revealed, and the control method of segregated frost heave based on "temperature control" was explored.

Assessment indicators:
(1) Reveal the migration mechanism of capillary-film water in the frozen edge zone, the freeze-thaw hysteresis mechanism of fractional ice, and the comprehensive mechanism of fractional ice formation, development and control;
(2) Explore the influence of temperature change on factors such as migration driving force, frozen soil tensile strength and water migration speed;
(3) Find the best temperature control method to control frost heave;
(4) Publish more than 2 SCI/EI papers, apply for 1 national invention patent, and participate in 1 important academic exchange conference at home and abroad.

Technical contact: Mr. Ding

Direction 25. Research on ecological toxicity prediction of coal-based solid waste backfill soil based on machine learning (general project)

Research content:
(1) Multidimensional data integration and feature selection. Collect multidimensional data such as heavy metal content, soil physicochemical properties, and biological growth indicators related to coal-based solid waste backfill, and use the gradient boosting tree algorithm to identify the key factors that have the greatest impact on soil biological toxicity.
(2) Toxicity risk assessment model construction. Based on the laboratory toxicity assessment results of plants, animals and microorganisms in coal-based solid waste backfill soil, machine learning models such as random forests and deep learning are constructed to predict the toxic effects of different pollutant concentrations on soil organisms. Through model training, the nonlinear relationship between pollutant concentration and biological toxicity is identified.

(3) Comprehensive analysis of ecological safety thresholds. Toxicity reactions under different scenarios are simulated, and an interpretable machine learning algorithm SHAP is constructed to identify the differences in sensitivity of different organisms to pollutants, analyze the ecological safety threshold of pollutants, and ensure the ecological safety of coal-based solid waste backfill utilization.

Assessment indicators:
(1) Database related to coal-based solid waste backfill utilization: Establish a multidimensional database containing data such as heavy metal content, soil physical and chemical properties, plant growth indicators, and microbial community structure;
(2) Machine learning feature selection model: Develop and verify a variety of feature selection, toxicity prediction, attribution interpretation and other models to identify the key factors that have the greatest impact on the biological toxicity of backfill soil;
(3) Publish 2 SCI papers.

Technical contact: Mr. Cheng

Direction 26. Nonlinear seepage diffusion law and evaluation method of geological storage process of carbon dioxide injection in coal seams (general project)

Research content:
Coal seam CO2 geological storage is a carbon storage technology with great development prospects. The microscopic pores and cracks of coal are extremely developed. The CO2 storage process is closely related to the microscopic effects of gas and water in coal. The seepage-diffusion evolution law and driving mechanism after injection into coal seams are unclear, which is the bottleneck for the evaluation of the injectability, storage potential and storage effectiveness of coal seam CO2 storage. Based on the non-steady-state heat-mass transfer and nonlinear seepage characteristics of the coal seam CO2 geological storage process, the adsorption characteristics of the coal body under different temperature-pressures are studied, and the response relationship between the micro-strain and macroscopic permeability of the coal body under the action of thermal-mechanical coupling is established; the seepage diffusion driving characteristics of the coal seam CO2 injection process are analyzed, and the CO2 storage migration trajectory is analyzed; the heat transfer, seepage diffusion, and adsorption-desorption strain models of the storage process are constructed, and the seepage evolution law under multi-field coupling is studied, revealing the microscopic mechanism of coal seam CO2 geological storage, evaluating the coal seam CO2 storage potential and effectiveness, and providing a theoretical basis for the industrial practice of coal seam CO2 geological storage.

Assessment indicators:

(1) Coal body full stress-strain mechanism and permeability evolution characteristics under thermal-mechanical coupling of CO2 injection into coal seams;
(2) Nonlinear seepage behavior and migration trajectory during CO2 injection and storage in coal seams;
(3) Non-steady-state multi-field coupling numerical model of heat and mass transfer-seepage diffusion for CO2 storage in coal seams;
(4) Seepage evolution law and microscopic action mechanism during CO2 storage in coal seams;
(5) Coal seam CO2 storage potential and effectiveness evaluation method;
(6) Publish 2 SCI papers (JCR Zone 1).

Technical contact: Mr. Sun

II. Application requirements

1. The project will no longer have a subject, and the total number of participating units will not exceed 3. In principle, the project research cycle will not exceed 2 years. In 2025, the laboratory will set up a total of 26 open fund projects, including 1 key project with a research funding amount of 1 million yuan; 25 general projects, each with a research funding amount of 150,000-250,000 yuan.
2. The unit where the project applicant is located should have independent legal person status, good R&D basic conditions and operating mechanism, and reliable technical foundation and economic support.
3. In principle, the project applicant should have a doctoral degree or a professional and technical title of associate senior or above, be under 45 years old, and have experience in undertaking or participating in scientific and technological projects at the provincial and ministerial levels or above. The conditions can be appropriately relaxed for outstanding candidates.

III. Other instructions

1. The project should be in line with the support direction, otherwise it will not be supported in principle.
2. The project is applied for by external personnel of the laboratory, and priority will be given to external personnel of China Coal Technology and Engineering Group.
3. The applicant's unit shall review the applicant's ability and level as well as the content of the application, put forward review opinions, promise to support the applicant's time and conditions, and affix the unit seal.
4. Project applicants with a record of serious scientific research dishonesty, a record of being on the credit "blacklist" in relevant social fields, a record of using various financial funds in violation of regulations, and a violation of scientific research integrity and ethics shall not apply.
5. In principle, the intellectual property rights (papers, monographs, patents, software copyrights, etc.) generated by the project research work belong to the laboratory supporting

unit, and the inventor and the unit have the right to use the intellectual property rights free of charge in scientific research and teaching activities. For all projects funded by this laboratory, the content of the research results published must strictly comply with the requirements of the open fund project contract (task book). The first completion unit must sign the State Key Laboratory of Intelligent Coal Mining and Strata Control, and indicate "Supported by the Open Funding of State Key Laboratory of Intelligent Coal Mining and Strata Control (Grant No.******)". Research results that are not marked in accordance with the regulations shall not be used as open fund project results for project completion acceptance.

6. Project applicants download and fill in the "Application Form for the Open Fund Project of the State Key Laboratory of Intelligent Coal Mining and Strata Control" (see Appendix 1) as required. The deadline for laboratory open fund project applications is June 6, 2025. Applicants should mail a paper copy of the signed and sealed application to: Coal Science and Technology Institute Community, Chaoyang District, Beijing before the deadline. State Key Laboratory of Intelligent Coal Mining and Strata Control (recipient: Mr. Cao, 13051533966), and send the electronic application form (Word and PDF signature format) to sklicmsc@163.com. Please indicate "the direction code of the applied fund + project name + applicant's name" in the email subject and electronic application form.

Appendix 1: Open Fund Project Application (Please scan the QR code to download the application)