CASTED

XV International Academic Conference 'Foresight and Science, Technology and Innovation Policy'

Navigating Expert-AI Synergy in Technology Foresight

YUAN Like

Institute of S&T Planning and Foresight

Chinese Academy of Science and Technology for Development（CASTED）

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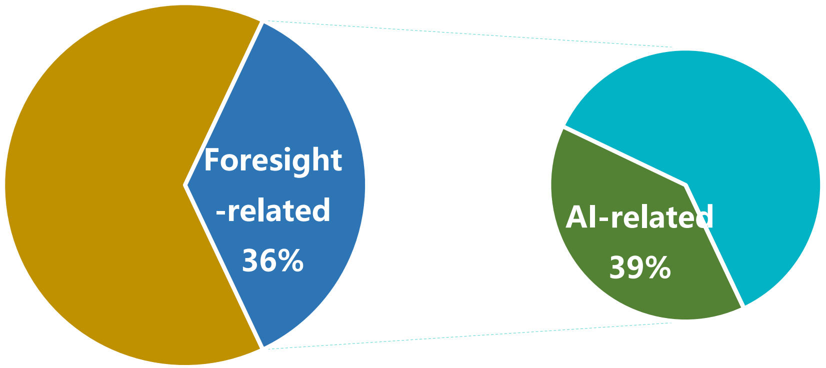
United Nations Educational, Scientific and Cultural Organization
联合国教育，科学及文化组织

International Research and Training Center for Science and Technology Strategy under the Auspices of UNESCO
国际科学和技术战略研究与培训中心



- Of the 46 abstracts related to Foresight, 18 of them referred to AI or Artificial Intelligence: These abstracts mainly explored the application, impact and challenges of AI in the field of foresight, and demonstrated the development trends and prospects of the combination of AI and foresight.
- Applications of AI in Foresight: such as "AI-driven Assessment of Grid Inertia" explore the application of AI in energy transition foresight.
- The impact of AI on Foresight methodology: such as "AI & Scenario Building" study the impact of AI on scenario building methods in foresight.
- Challenges and opportunities of combining AI with Foresight: such as "The K.I.R. Framework for Transforming Participatory Futures" analyze the challenges and opportunities brought about by the combination of AI and foresight.
- These abstracts suggest that AI is gradually penetrating the foresight field, providing new impetus and possibilities for the development of foresight.

Definitions and methodological systems

- Technology Foresight is a systematic study of scientific, technological, economic and social development over a long period of time in the future, with the aim of identifying strategic research and selecting groups of technologies that make the greatest contribution to economic and social benefits.
- The core spirit of foresight lies in participation and communication, integration to achieve a rational consensus effect, reduce resistance to technological development, and enhance the centripetal force of technological innovation.

Objective: To provide important support for strategic decisions on science and technology development, while forming strategic priorities that reflect the will of the state, to guide extensive cooperation throughout society through technology foresight and to guide the allocation of social resources in areas conducive to the realization of the country's macro science and technology strategic goals.

- The technology foresight activity is a complex and systematic process involving several links and requires the integration of multiple methods to be accomplished. In the early days, methods such as trend extrapolation and modeling were mainly used for technology forecasting. In the 1970s, Japan began to use the Delphi survey for large-scale technology forecasting. Since then, the methodological system has been continuously improved and multiple methods have been comprehensively applied. Methods such as bibliometric analysis, demand analysis, scenario analysis, horizon scanning, and big data analysis have been successively introduced into technology foresight activities. Over the past half-century, the methodology of foresight has been evolving, with the aim of making various efforts to reduce distortion.

Technology foresight and method evolution

The first generation
Technology

Second generation
Technology - Market

Third generation
Technology-market-society

Fourth generation
System

Fifth generation
Complex Policies

Similar to relying on individual experts, there is no formal approach

Ogburn and Gilfillan contributed to early technology forecasting using quantitative methods.

Major developments in technology forecasting and future research. The RAND Corporation developed the Delphi forecasting method.

Focus on population growth and resource use, such as "Limits to Growth" (1972). Japan uses the Delphi method for national foresight.

"Foresight" became a formal term in the 1980s and there were many country-level foresight in Europe in the 1990s.

Technology foresight became more extensive, including local and regional institutions, and shifted towards problem-driven, particularly around major challenges, incorporating issues that technology assessments often address.

Social quantitative prediction

Expert Predictions

Trend extrapolation

Modeling

Delphi Survey

Technology Roadmap

Scenario analysis

Quantitative methods: Conduct predictive research using methods such as bibliometrics, patent analysis, text mining, and social network analysis. Auxiliary methods: SWOT analysis, TRIZ method, stakeholder analysis, expert system, etc.

The trend of digital and intelligent transformation is obvious. Foresight research is carried out by means of machine learning and time series foresight methods, building LDA topic models, extracting patent texts, etc.

1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

The Great Depression

World War II, the Cold War, post-war prosperity, the space race, decolonization

The Vietnam War, cultural and political turmoil, the rise of emerging industrialized countries in Asia

The development of microelectronics technology, the .com bubble, focus on climate change

9/11, financial crisis, geopolitical conflict, climate change impact

From traditional approaches to Ai application in foresight

Time consuming: traditional methods require long planning cycles, workshops, and data analysis

Decentralized and fragmented: information is scattered across different departments or experts

Limited data handling: difficulty in processing large volumes of data or detect patterns in real-time

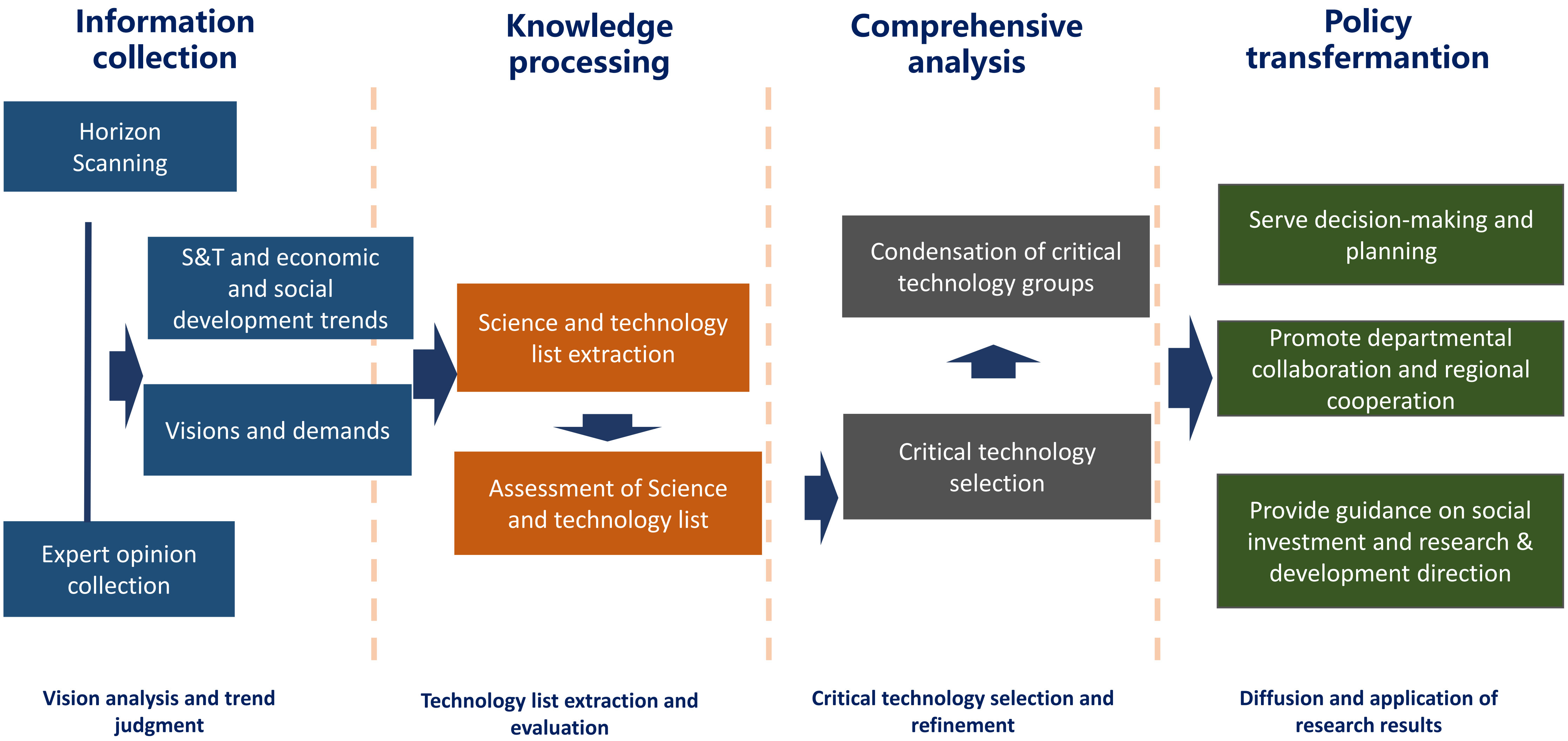
Subjectivity: depend on expert opinions which introduce personal bias in foresight processes

Scenario simulation: AI large models can simulate the industrial ecosystem under different technological paths, such as the impact of autonomous driving on urban traffic, helping to identify "black swan" events (such as supply chain disruptions) and formulate response strategies in advance.

Trend analysis: Discover the convergence points of technologies through knowledge graphs, and monitor the technology maturity curve in real time to adjust the priority of R&D.

Demand analysis: Predict market demand by integrating social media and user behavior data.

Priority Technology selection: Simulate the input-output ratios of different technology routes, such as choosing the MoE architecture to reduce inference costs. The above methods need to be used in combination to deal with the complexity and uncertainty in technology foresight.



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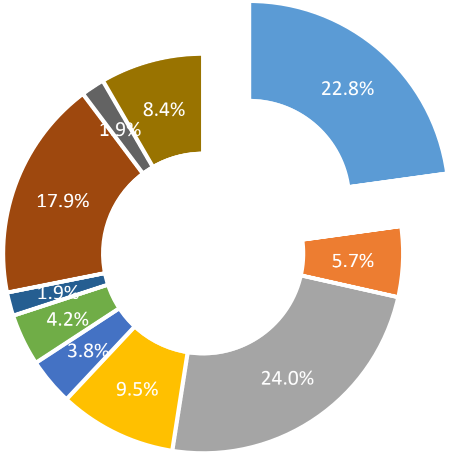
Vision analysis and trend judgment | Technology list extraction and evaluation | Critical technology selection and refinement | Diffusion and application of research results

Institutions	Report	Year	Main Contents
NIC	Global Trends 2040	2021	Trend challenges, scenarios
NISTEP Japan	Ideal society in 2040	2019	Trends, Visions, Demands
KISTEP Korea	Future Society Projections	2021	Trend challenges, demands
German BMBF	Trends and Themes Analysis of the Future Office	2019	Trends, Issues
UK Government Science Office	Trend Card 2021	2021	Trends
A.t. Kearney	Global Trends 2022-2027	2022	Trends, Challenges
American Institute for the Future	2022-2032 Decade Map	2022	Trends, Challenges
...			

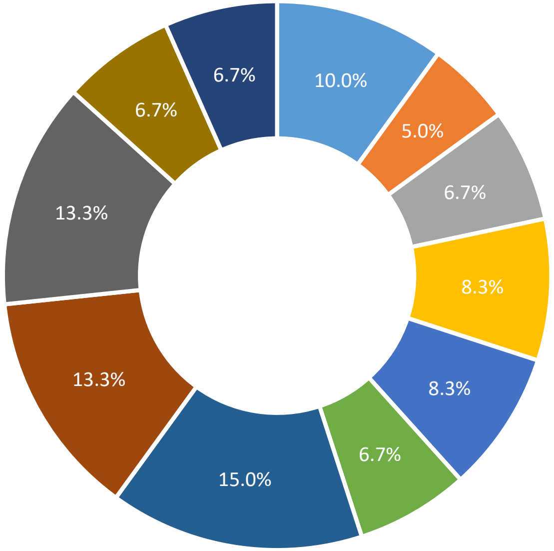
Scenario simulation: simulate future economic and social scenarios. For instance, the future industrial ecosystem under different technological paths, social issues caused by population aging, the impact of autonomous driving on urban traffic, and helping to identify "black swan" events (such as supply chain disruptions), etc., to formulate response strategies in advance.

Vision analysis and trend judgment | Technology list extraction and evaluation | Critical technology selection and refinement | Diffusion and application of research results

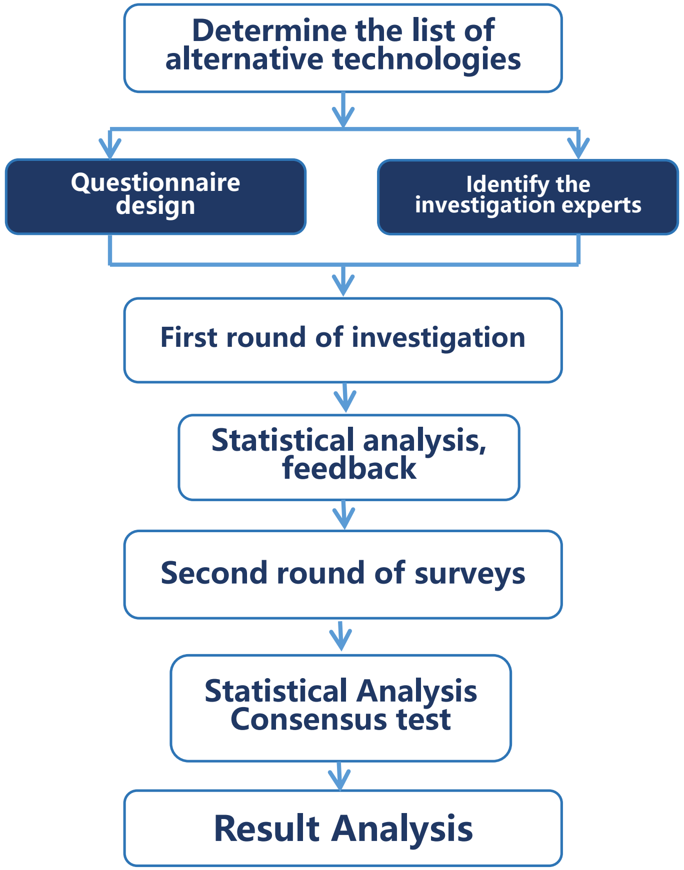
Technology hotspots and trend analysis: By leveraging big data knowledge graphs such as patents and papers, identify technology convergence points, monitor the maturity curve of technologies in real time, discover hot research directions, and adjust R&D priorities.



- artificial intelligence
- new energy
- Biology and Health
- electric vehicle
- Quantum computing
- integrated circuit
- Industry and Engineering
- Materials and Chemistry
- Physics and Astronomy
- Resources and Environment

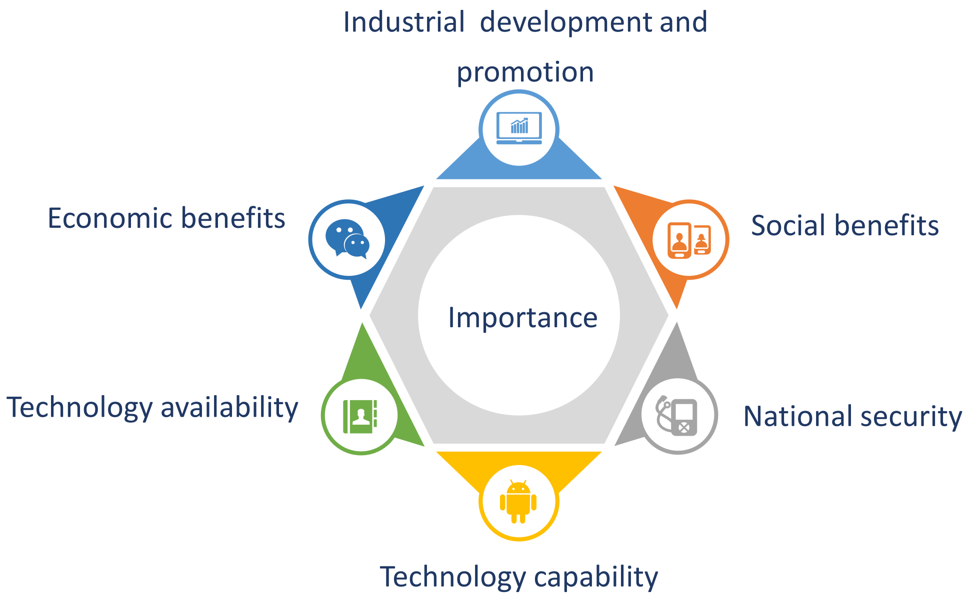


- Artificial Intelligence Applications and Ethics
- Information Security and Data Privacy
- Advanced communication technology
- Blockchain and Its Applications
- Image Processing and Computer Vision
- Satellite Remote Sensing Analysis Based on Intelligent Algorithms
- Smart healthcare
- Intelligent robots and human-machine interaction
- Deep learning models and optimization algorithms
- Natural Language Processing and Recommendation System
- Edge cloud computing and serverless computing



- Importance index
- The technological gap with leading countries
- Current R&D capabilities
- Technology development path
- The effect on the development of high-tech industries
- The effect of transforming and enhancing traditional industries
- The effect of environmental protection and comprehensive development and utilization of resources
- The effect of improving people's quality of life
- The effect of improving international competitiveness
- Industrialization prospects
- Independent intellectual property rights in the next 5 years
- Time to achieve industrialization (generating social benefits)
- Suggested measures to be taken
- Your suggestions on this technology (express your opinions freely)

Do Something but not Everything



Importance. It is crucial for the development of the national economy and ensuring national security, and technological innovation and application play a decisive role in economic development.

Universality. These technologies have broad application fields and can promote the development of various industries.

Driving force. These technologies can drive the progress and development of multiple technologies.

Practicality. These technologies must be able to be applied in a relatively short period of time (5-10 years) and be compatible with other technologies to create products, equipment, systems, or engineering with good market demand.

Dynamic updates. Critical technologies are not fixed, but constantly adjusted and updated according to the strategic goals of national development, international competitive environment, national economic and technological capability.

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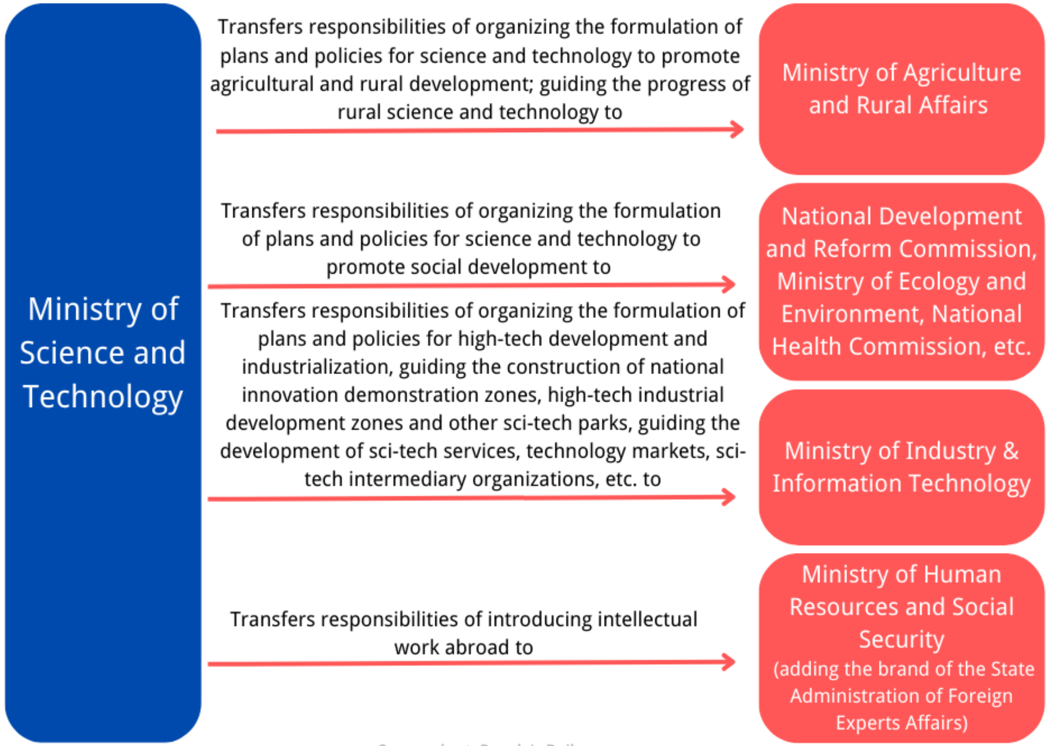


Source chart: People's Daily
Translated and remade by Ginger River Review

Serve decision-making and planning

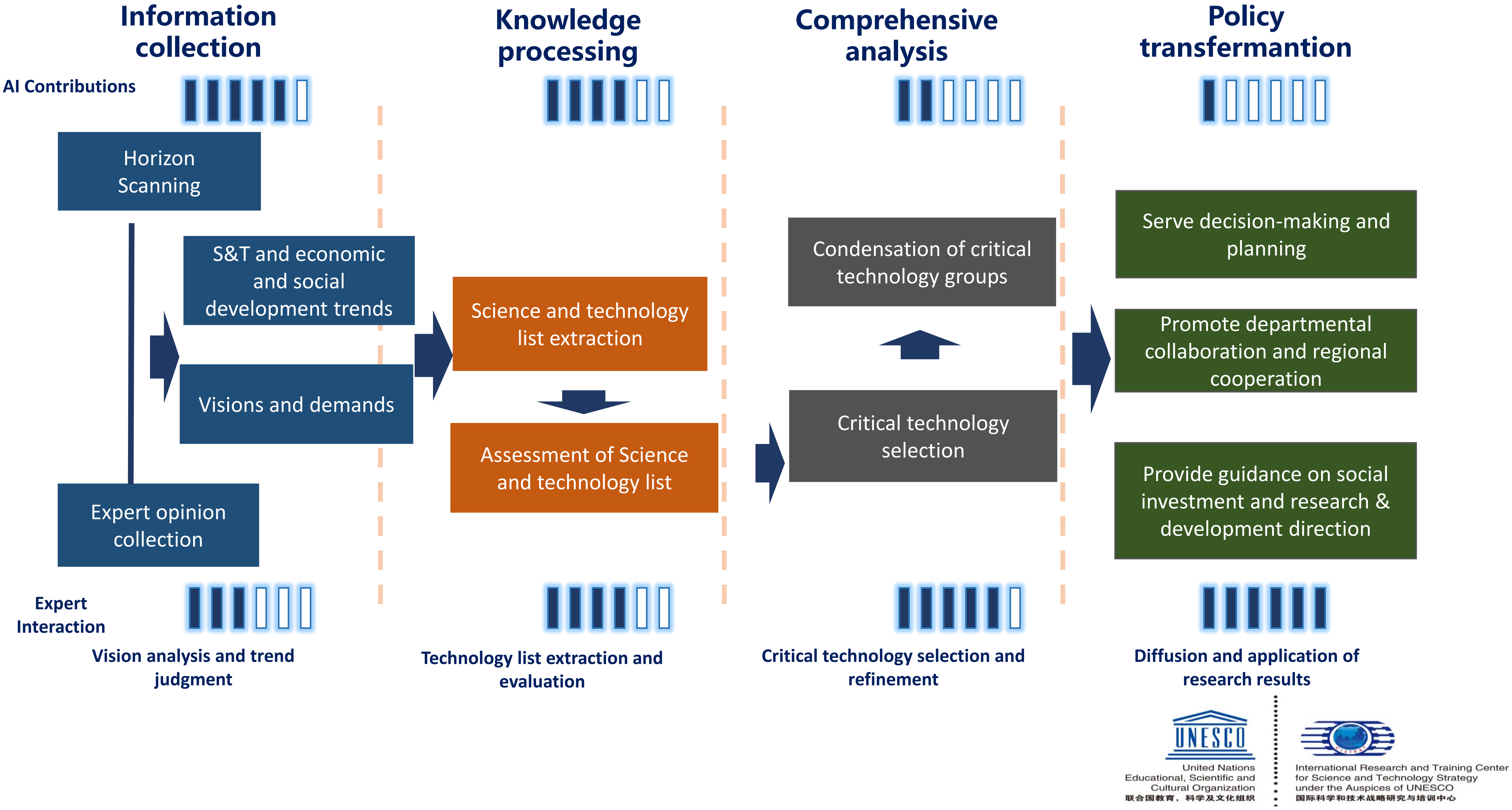
Provide a list of key technologies
Provide recommendations for the deployment of major science and technology projects

Promote departmental and regional collaboration

Propose major research tasks across departments
Provide a foundation for local foresight efforts

Guide social investment and research and development

Publish research reports on technology foresight
Formulate a roadmap for the development of critical industrial technologies


Information collection
Knowledge processing
Comprehensive analysis
Policy transfermantion
AI Contributions
Horizon Scanning
S&T and economic and social development trends
Visions and demands
Expert opinion collection
Science and technology list extraction
Assessment of Science and technology list
Condensation of critical technology groups
Critical technology selection
Serve decision-making and planning
Promote departmental collaboration and regional cooperation
Provide guidance on social investment and research & development direction
Expert Interaction
Vision analysis and trend judgment
Technology list extraction and evaluation
Critical technology selection and refinement
Diffusion and application of research results
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Technology foresight must rely on experts because they have a deep understanding of how technology works inside and the domain of practical problems that technology aims to solve. It is almost unimaginable to form judgement of new technologies relying solely on quantitative methods without the support of experts.

[redacted]

Field Group leader

××× subfield
Team Leader

[redacted]

××× subfield
Team Leader

[redacted]

Core Expert Group

[redacted]

Investigation experts

[redacted]

The size and quality of the data are difficult to meet the requirements of intelligent algorithms. The inherent characteristics of big data itself, the increasing proportion of visible noise and signals can mislead the signals in big data, making the extraction of valuable signals more complex and thus distorting the accuracy of foresight.

The explainability of the process is controversial. The process of foresight is like a black box, which generates its own rules and models based on the input data and specific algorithms to produce the foresight results, but how the rules and models are generated may not be clear to the scientists themselves, nor can they provide a clear scientific causal explanation. This unexplainability often makes it difficult to hold people accountable when AI is used to assist or replace human decision-making.

High demands for financial investment and talent development. Intelligent algorithms rely on continuous research and development and technical support, including algorithm development, model training, etc., with high operation and maintenance costs. Experts who can understand machine language and have good predictive skills are needed.

- Develop data science and strengthen the research and development of critical technologies for big data intelligent foresight
- Optimize the decision-making process and standardize the governance of big data intelligent foresight technology
- Strengthen intelligent assistance and build a system of "intelligence-expert" technology foresight methods

Combine with AI methods in the foresight preparation stage to define the target, conceptual model, and search boundary. When aiming to identify emerging topics and their potential impact in a given domain (which is often the goal of the foresight process), building a new knowledge graph to avoid path dependence and reliance on past situations can significantly improve the quality of the results of the foresight process.

Leverage the scanning advantages of big data intelligent methods, collect data and conduct system tests to identify potential threats and development opportunities. Scanning can explore new and unexpected problems, as well as persistent issues, trends, and weak signals or future signals (i.e., early signs of emerging topics) that have become a standardized process in foresight practice.

New directions identified during the scanning phase create a list of potential weak signals or trends (i.e., potentially fast-growing topics) and evaluate them as future developments as emerging topics. This can expand the cognitive boundaries of strategic decisions or policy-making and determine future strategic directions.

Thank you!

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