2021
China AI Development Platform Market Report

LeadLeo Research Institution
Frost & Sullivan (China)

Instruction

Sullivan hereby releases the '2021 China AI Development Platform Market Report' annual report of the China AI series of reports. This market report takes the development platform products in the field of artificial intelligence as the core research object, and the research cycle covers the whole year of 2020. This research project will focus on sorting out information about market trends, cutting-edge technologies, business models, and competitive trends in the field of artificial intelligence, and make speculations or predictions about market development prospects from dimensions such as application scenario expansion and ecological value creation.

This research project aims to sort out the artificial intelligence development platform service system, gain insights into user characteristics, market stock space and incremental space. It also studies and determines the position of various competitors in the artificial intelligence development platform industry based on the market development prospects.

The results of this study will use the growth index to reflect the ability of competitors to maintain their current market position, and the innovation index to reflect the ability of competitors to further improve their market position.

The data in all figures, tables, and texts in this report are from Frost & Sullivan Consulting (China) and LeadLeo Research Institute surveys. The data are rounded to one decimal place.

- **Self-developed AI chips, cloud native architecture, flexible distributed training services, and MLOps capabilities have become the core capabilities of the platform**

AI chips will continue the trend of architectural innovation, morphological evolution, and integration of software and hardware. Cloud-native applications can provide users (developers) of AI development platforms with more agile and high-quality application delivery and simpler and more efficient application management. Distributed training can provide flexible configuration of the underlying resources and improve the resource utilization of the system. MLOps brings flexibility and speed to the AI development platform.

- **Developer traffic and platform scale are the two decisive elements of AI development platform's revenue**

The business model of AI development platform is relatively simple. It profits by providing companies or developers with AI technology interfaces or AI development tools. The billing methods mainly include free mode, billing based on call volume and annual or monthly subscription.

- **Model call business's revenue will increase**

From 2016 to 2020, the revenue of China's AI development platform has expanded rapidly. In 2020, the revenue of China's AI development platform will exceed 20 billion RMB. At this stage, its four businesses, namely, computing power, data, model invocation, and deployment/maintenance, account for about 4:3:2:1 in the total revenue of the AI development platform. In the future, as the proportion of inferred applications increases, the proportion of data business revenue is expected to decline. With the deepening of the application of AI in various vertical scenarios, the proportion of model call business revenue is expected to increase.

Table of Contents

图表目录

Chapter 1

Platform Structure

AI Chips、Cloud Native Structure、Elastic Training and MLOps are becoming key indicators

Platform Structure

> **Self-developed AI chips, cloud native architecture, flexible distributed training services, and MLOps capabilities have become the core evaluation indicators of the platform**

- ❑ Artificial intelligence development platform is a platform that integrates AI algorithms, computing power and development tools, open machine learning, deep learning and training model. It also provides computing power to support the development procedure. Through the form of interface invocation, developers can efficiently realize AI product development or AI empowerment.

- ❑ The AI open platform provides developers with tools and frameworks such as AI datasets, AI models and computing power to help reduce development costs. Developers can use the platform's data sets to train their models, or use the platform's algorithmic framework to customize functions they need.

- ❑ AI development platform architecture can be divided into four layers from bottom to top: infrastructure, framework tools, training platform and technical services.

1. Infrastructure: Self-developed AI chips are the core competitiveness of enterprises. Self-developed chips have the trend of framework innovation, morphological evolution and integration of both software and hardware

1.1 Basic hardware

- ❑ Currently, the mainstream AI processor is essentially a system-on-chip (SoC), which can be mainly applied in scenes related to image, video, speech and word processing. The main components of an AI processor include a specialized computing unit, a large storage unit, and a corresponding control unit. By developing their own AI chips, enterprises can adapt the chip circuit framework to their own algorithms to maximize the efficiency of computing. Self-developing AI chips will gradually become one of the core competitiveness of AI development platform enterprises.

AI development platform structure

AI technical services	**Services based on speech recognition, image recognition and text recognition; the construction of AI ecosystem**
AI training platform	**Machine learning platform**
AI framework tools	**Machine learning frameworks represented by Tensor and PyTorch**
AI infurstruc-tures	**Including basic hardware (CPU、GPU、FPGA、NPU、ASIC and SoC); calculation engine、cloud container**

Source: Frost & Sullivan

1.1.1 AI Chip architecture innovation

- ❑ Cloud AI chips are mainly used in AI training scenarios, and computing power is one of its core metrics. In order to adapt to the applications and algorithms that need to be used in AI training, AI development platform suppliers need to develop domain-specific architecture (DSA) chips to innovate the architecture and achieve the goal of chip performance optimization. Take Huawei's Ascend chip as an example. Huawei uses the Da Vinci architecture to enhance the computing power of AI chips. Among them, the computing unit, as one of its three major components (calculation, storage and control), can perform scalar, vector and matrix operations. Huawei has deeply optimized the matrix operation in the Da Vinci architecture and customized the corresponding matrix calculation unit to support high-throughput matrix processing. This is embodied in that the Ascend chip can complete the multiplication operation of two 16*16 matrices with one instruction.

- ❑ In order to solve the problem that the existing memory access speed is seriously lagging behind the computing speed of the processor, new fully programmable, reconfigurable architecture (CGRA) chips, memory computing chips, and a new processor architecture IPU or IPU with high storage bandwidth may will be introduced into the underlying ecology of AI chips.

- ❑ In addition, chip programming methods and software architecture design will also become an important link in AI chip innovation. For example, NVIDIA uses its CUDA framework to greatly reduce the programming difficulty of its GPU, allowing GPUs to be widely used in AI acceleration. In the future, more AI processors will provide multi-layer software stacks and development tool chains to help developers use the underlying hardware resources more effectively, improve development efficiency, and reduce the defects of low flexibility of dedicated chips through the diversity of software.

1.1.2 AI Chip morphology evolution

- ❑ One of the AI chip innovation goals is to maintain the high energy efficiency ratio of the chip while adapting to the evolution of AI algorithms. In the future, the system-on-chip form of general-purpose and dedicated chips will become the mainstream (CPU+NPU, CPU+ASIC, etc.) and have a wider range of applications.

Source: Frost & Sullivan

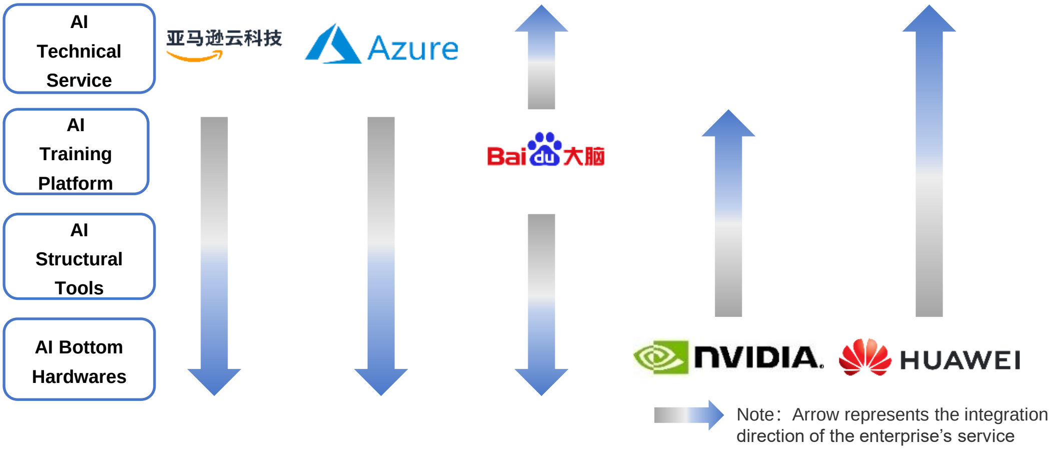
- The traditional processor instruction set (including x86 and ARM, etc.) is constantly evolving in order to perform general-purpose calculations. Its basic operations are arithmetic operations (addition, subtraction, multiplication, and division) and logical operations (and or not), often requiring hundreds of instructions to complete the in-depth learning procedure of a neuron's processing. The processing efficiency of deep learning is not high. In order to solve the second pain point, the chip shape needs to break the traditional Von Neumann architecture. The neural network processor NPU uses circuits to simulate the structure of human neurons and synapses. In the NPU, the integration of storage and processing in the neural network is embodied by synaptic weights. For example, the DianNaoYu, the world's first deep learning processor instruction set proposed by the Cambricon, can directly face the processing of large-scale neurons and synapses. A group of neurons can be processed with one instruction, and the processing of neurons and synapses can be completed. The transmission of data on the chip provides a series of specialized support. In the cloud application, the Alibaba Cloud server AN1 equipped with the T-Head Hanguang NPU, in the inference application of the ResNet50 model, the Hanguang NPU can process up to 78,000 IPS images per second, which is double the performance of similar processors.

1.1.3 AI Chip software and hardware integration

- The software tools surrounding AI chips began to shift from basic computing to scene computing. In the past, chip companies represented by NVIDIA continued to build a multi-level basic software tool ecosystem such as high-performance operator libraries, communication algorithms, and inference acceleration engines centered on the CUDA programming model. At this stage, the leading AI chip companies have begun to build an integrated software and hardware platform for differentiated scenarios. The business model has expanded from the provision of hardware support services to the provision of technical production tools and technical services, and the realization of underlying chips, programming frameworks, industry algorithm libraries, and detailed full-stack and efficient integration of R&D platforms by scenes to cultivate a computing ecology for diversified industry scenes and seize market segments. At the same time, companies can also provide modular services according to customer needs, provide customers with less capable services, and enhance the degree of customization of services.

Source: Frost & Sullivan

The whole integration of AI development platform

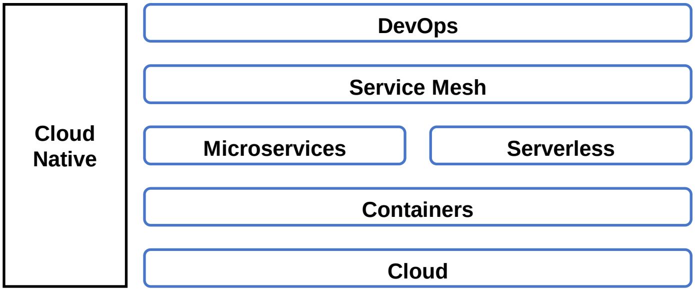


Note：Arrow represents the integration direction of the enterprise’s service

1.2 Cloud Native

❑ Cloud native technologies enable organizations to build and run applications that can scale flexibly in new dynamic environments such as public, private and hybrid clouds. Cloud native technologies include containers, service grids, microservices, immutable infrastructure, and declarative apis. These technologies enable the construction of loosely-coupled systems that are fault-tolerant, easy to manage, and easy to observe. Combined with reliable automation, cloud native technology enables engineers to easily make frequent and predictable significant changes to systems. At the infrastructure level, containers decouple application and technical architecture resources between cloud infrastructure and applications. At the application level, users can choose microservice architecture or no server architecture based on the scenario. In complex architecture scenarios, the communication of service components is controlled by service grid. Finally, the system was updated iteratively through DevOps.

The cloud native concept closed loop



Source: Voice-of-Nico, Frost & Sullivan

- **Improvements in infrastructure：** The deep learning training platform based on cloud native can achieve complete container deployment and use, and provides elastic expansion of resources based on Kubernetes (K8s), scheduling and allocation of resources under different tasks, and is compatible with a variety of cpus and GPU processors downward. Therefore, the AI development platform based on cloud native can be quickly adapted to appropriate cloud native resources, no matter for trainings of large-scale sparse data or training of perception-oriented scenarios. For example, Alibaba Cloud PAI can provide a kernel that supports nearly linear acceleration, which enables training tasks to achieve performance enhancement and performance acceleration on a variety of engines.

- **Improvements in training links：** Cloud-native container architecture can flexibly allocate computing power resources of machine learning training and reduce cost and increase efficiency for AI development through elastic training. AI development platform's cloud can monitor the computing power of the resource pool in real time and allocate idle computing resources to the task in training when there are idle computing resources, so as to improve the computing power of the task and make the training operation converge quickly. After the task is submitted, the elastic training scheme can recycle the resources and allocate them to a new machine learning training task according to the usage of free resources in the resource pool and elastic jobs, which can ensure the computing power of the new machine learning training.

- **Improvement of user experience:** Cloud native applications can provide users (developers) with more agile and high-quality application delivery, simpler and efficient application management, faster response to business needs, and better user experience. Based on cloud native, the AI develop platform is a perfect fit for the team's online AI collaborative development, online AI teaching and the local migration to the upper cloud of AI research and development.

Source: Frost & Sullivan

2. Structural Tools: Lead by Google TensorFlow and Facebook PyTorch

- ❑ At the initial stage of AI development platform construction, it is necessary to build the underlying technical framework, mainly referring to the deep learning framework. When building the underlying framework of the platform, platform operators can choose independent research and development or use external framework, both of which have advantages and disadvantages. Due to the high technical threshold of independent research and development, most manufacturers use external open source framework.

  - **Independent research and development：** The advantage of independent research and development is that the platform will not be subject to ecological constraints. Take Google's TensorFlow as an example. If platform operators use TensorFlow as the underlying framework of deep learning, their hardware APIS will only be connected to TensorFlow, which is deployed on Google Cloud. That makes the platform dependent on Google's ecosystem. The self-developed deep learning framework will give platform operators more freedom to play and reduce their dependence on external ecology. However, the threshold of framework development is high, the cycle is long, and the cost is high. Take Baidu for example, baidu established the Deep Learning Research Institute in 2013, during which a large number of relevant scientists and engineers participated in the research and development, and it took three years to release the PaddlePaddle framework of deep learning.

  - **Using external structures：** The main advantage of using external frameworks is that most external frameworks are open source and can be used directly by platform operators, which can effectively reduce the cost of platform construction and shorten the development cycle. The extra time and cost saved can be used for the development of its supporting tools. The disadvantage is that the use of external frameworks needs to rely on external ecology, which is not conducive to the construction of the platform's own ecology.

- ❑ Over 90% of the global deep learning framework is occupied by TensorFlow developed by Google and Pytorch developed by Facebook:

  - TensorFlow is the most popular deep learning framework currently. It has features such as visualization, powerful performance, and multi-purpose. TensorFlow comes with a tensorboard visualization tool that allows users to monitor and observe the training process in real time. It also supports multi-GPU and distributed training and has strong cross-platform operation capabilities. TensorFlow has multiple uses not limited to deep learning. It also has tools that support reinforcement learning and other algorithms.

Source: Frost & Sullivan

- PyTorch is open sourced by Facebook, with features such as simplicity, ease of use, and detail. PyTorch has less abstraction and more intuitive design, the modeling process is simple and transparent, what you think is what you get, the code is easy to understand, and it can provide users with more details about the implementation of deep learning, such as backpropagation and other training processes. PyTorch has a more active community that can provide developers with complete documentation and guides for users to communicate and ask questions. But this community is smaller than the Tensorflow community.

- Other typical frameworks include Keras (open sourced by Google engineers), mxnet (open sourced by Amazon), PaddlePaddle (open sourced by Baidu), theano (open sourced by the University of Montreal), CNTK (open sourced by Microsoft). Among them, CNTK, Japanese startups preferred networks, Chainer, Theano and other early popular frameworks have left the race by merging with mainstream frameworks or directly stopping updates.

- The competitive landscape of the AI development platform framework has gradually become clearer: TensorFlow continues to rank first, relying on the deployment advantages of the industry. TensorFlow is more than 3 times concerned by the market compared to the PyTorch, who ranked second. After merging with Caffe2, PyTorch has greatly increased its application prevalence due to its ease of use. It has been used for more than 50% among the top academic conference papers.

- China is also rapidly adopting a systematic layout of open source development frameworks. Representative projects include Baidu PaddlePaddle, Megvii MegEngine, Huawei MindSpore, and Tsinghua University Jittor. Baidu PaddlePaddle is the first to be launched, and it has been initially applied in industrial, agricultural, and service industries. Its application depth is gradually improving. Baidu PaddlePaddle has more than 2.3 million developers, which makes it to be the largest open-source development framework in China.

Source: Frost & Sullivan

3. Training platform: lower costs and increase efficiency through flexibly distributed training

3.1 Resource allocation

❑ According to the fitting of real data, the amount of AI computation increases at least 10 times every year, which exceeds Moore's Law by 18 months. Therefore, the ability to adjust task resources in deep learning training becomes particularly important. With the expansion of cluster scale currently, the possibility of machine breakdown at a given moment in the cluster is increasing.

❑ With the increase of training model’s complexity, training resources and training time increase significantly while the fault tolerance of the task decreases. In addition, as the cluster scale increases, the waste of idle resources becomes hard to ignored, and the demand for a more flexible allocation of cluster resource is increasing constantly.

❑ Distributed training provides elastic allocation of underlying resources. It also improves system resource utilization rate. For instance, Baidu PaddlePaddle can segment tasks through its general heterogeneous parameter server. Consequently, users can deploy distributed training tasks in heterogeneous hardware clusters and realize more efficient utilization of chips with different computing power. This provides users with training capacities which have higher throughputs and lower resource consumption.

❑ However, the application of distributed training also has many obstacles. To meet the huge workload may flexible training generate, developers should be able flexibly control elements in each framework and ensure the suitability of corresponding systems. In addition, if different frameworks have their own flexible training solutions, the integration of different frameworks in the AI development platform will generate high maintenance costs.

❑ Elastic distributed training is the trend of AI development platform services, which can reduce costs and increase efficiency for users. When users need a large number of computing resources, it can expand capacity, improve computing power and stability, and reduce model training time. When the user’s computing demand is small, it reduces the underlying resource configuration and the service costs caused by resource occupation.

Source: Frost & Sullivan

3.2 Algorithm upgrades

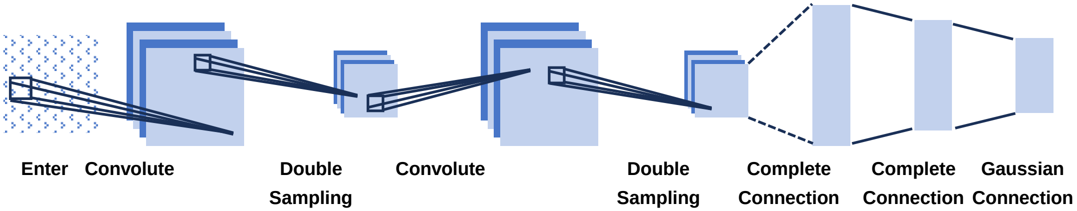
❑ Algorithm is the link between AI and big data. Internet applications such as social media, location technology, and search engines generate and store large amounts of data in real time. On the basis of massive amounts of data, AI continues to infer the interests, preferences and needs of users, generates different user portraits, and realizes the entire personalized and precise customization of digital culture from production, dissemination to acceptance.

❑ At this stage, the AI training platform has integrated or will integrate a variety of artificial intelligence technologies, such as computer vision, natural language processing, cross-media analysis and reasoning, intelligent adaptive learning, swarm intelligence, autonomous unmanned systems, and brain-computer interfaces, etc.:

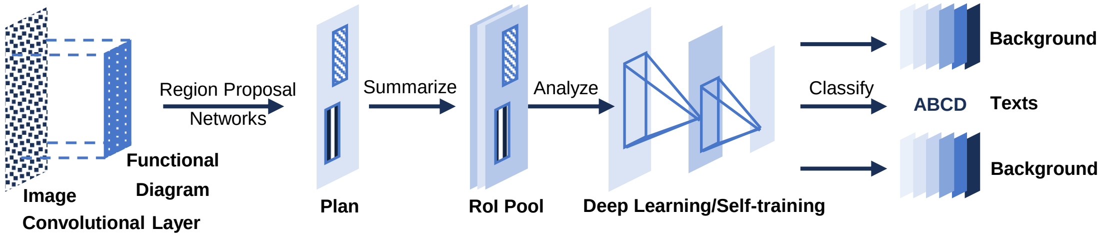
- **Computer vision technology:** using cameras and computers instead of human eyes to identify, track and measure targets, and to perceive the environment in three dimensions.
- **Natural language processing technology:** Analyze, understand and process natural language by establishing a formal calculation model.
- **Cross-media analysis and reasoning technology:** collaborative and comprehensive processing of multiple forms, such as text, audio, video, image and other mixed and coexisting composite media objects.
- **Intelligent adaptive learning technology:** simulate the one-to-one teaching process of teachers and students and give the learning system the ability of personalized teaching.
- **Swarm intelligence technology:** the process of gathering multiple opinions into decision-making, reducing the risk of a single individual making random decisions.
- **Autonomous unmanned system technology:** A system that is operated or managed through advanced technology without manual intervention.
- **Brain-computer interface technology:** a direct connection channel established between the human or animal brain and external equipment to complete information Exchange.

Source: Frost & Sullivan

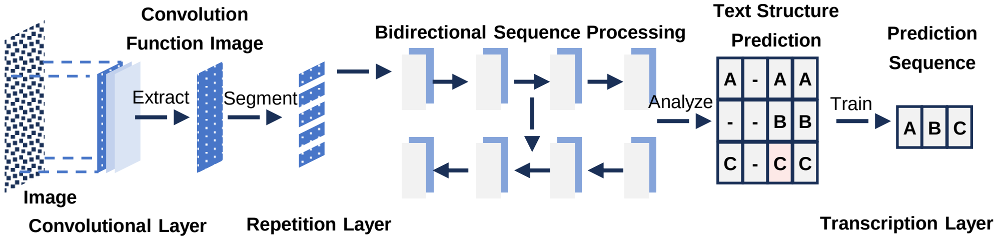
Principles of image preprocessing technology



Principles of text detection technology



Principles of text recognization technology



A	-	A	A
-	-	B	B
C	-	C	C

A	B	C

Source：Frost & Sullivan

❑ As the prevalent application of AI learning methods in financial, medical, social and other scenarios create huge amounts of data, the AI training algorithms will be constantly trained. example, a paper of CVPR 2021 proposes a new convolutional layer named skip-convolutions, which can subtract the two frames of images and convolute only the changing part. In the image preprocessing technology, the neural network based on CNN is used as the feature extraction method, and CNN's strong learning ability can also enhance the robustness of feature extraction in the AI model. The FrameExit network, which consists of multiple cascade classifiers, can vary the number of neurons used by the model depending on the complexity of the video frames, so that when the difference between the front and back frames is large, the AI will use the whole model, and when the difference between the front and back frames is small, the AI will only use a part of the model.

4. Technical service： MLOps can enhance team efficiency

❑ With the development trend of industrial intelligence, AI is becoming a universal technology for transformation and upgrading of many industries. At present, the most mature and extensive application areas of AI include public security, transportation, finance, education, etc. The application requirements of AI in other industries are highly dispersed and the scenarios are also diverse, but the application requirements of AI still exist widely. Aiming at different application scenarios, the AI development platform can provide cloud-based natural language understanding, automatic speech recognition, visual search, image recognition, text-to-speech conversion, machine learning hosting and other services. The AI development platform can provide developers or business users with convenient operations for building advanced text and voice chat robots, intelligent machine learning applications, etc.

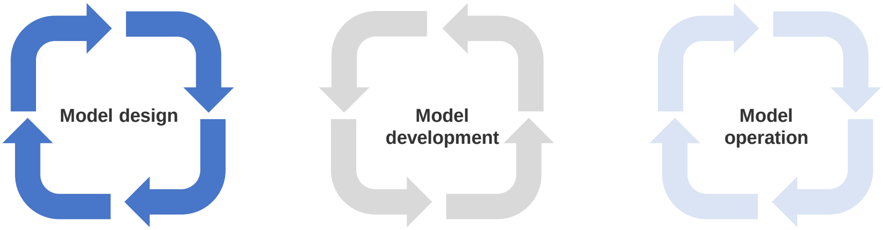
❑ For individual or enterprise developers, development time and development cost are the main consideration indicators for building AI applications. With the help of cloud native and flexible distributed computing architecture, users can reduce costs and increase efficiency at the level of AI model training and inference. With the help of MLOps, the team's development and deployment efficiency will be significantly improved.

Source: jdon, AI Discovery, Sullivan

- ❑ MLOps is ML's DevOps. The machine learning (ML) model built by data scientists needs to work closely with other teams (business team, engineering team, operations team, etc.). Teamwork poses challenges for communication, collaboration and coordination, and the goal of MLOps is to simplify such challenges through sound practices. MLOps brings flexibility and speed to the system: MLOps reduces development time and obtains high-quality results through reliable and effective ML lifecycle management; MLOps continues continuous development (CD), continuous integration (CI), and continuous development from DevOps. Training (CT) and other methods and tools ensure the repeatability of AI workflows and models. Developers can easily deploy high-precision machine learning models and integrated management systems to continuously monitor machine learning resources anytime and anywhere.

- ❑ MLOPs also put forward higher requirements for the platform's data and hyperparameter version control, iterative development and testing, testing, security, production monitoring, infrastructure and other links. MLOps platform data plays an equally important role in defining output as written code, so the data complexity is improved compared to DevOps platform. In response to the challenges faced by the MLOps platform, the implementation process of MLOps includes five stages: use case discovery, data engineering, machine learning pipeline, production deployment, and production monitoring. Its workflow is mainly realized through agile methods.

MLOps concept：MLOps=ML+DevOps



Model design

- **Demand engineering**
- **ML case priority**
- **Data usability inspection**

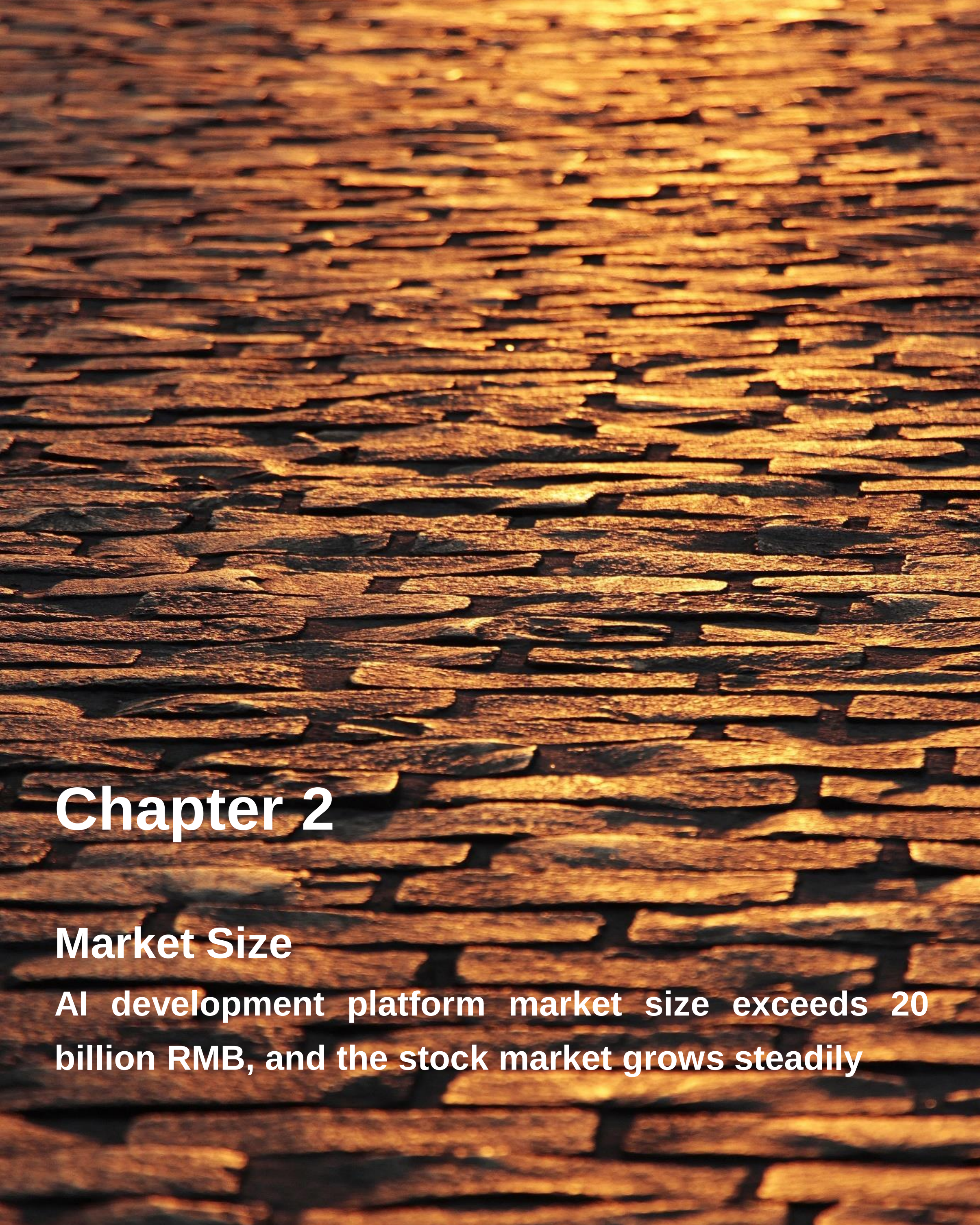
Model development

- **Date engineering**
- **Machine learning model engineering**
- **Model test and verification**

Model operation

- **Machine learning model deployment**
- **CI/CD Channel**
- **Monitoring and trigger**

Source: jdon, AI Discovery, Sullivan



Chapter 2

Market Size

AI development platform market size exceeds 20 billion RMB, and the stock market grows steadily

Business Mode

“The business model of AI development platforms is relatively simple. Developer traffic and platform size are two decisive factors for revenue.”

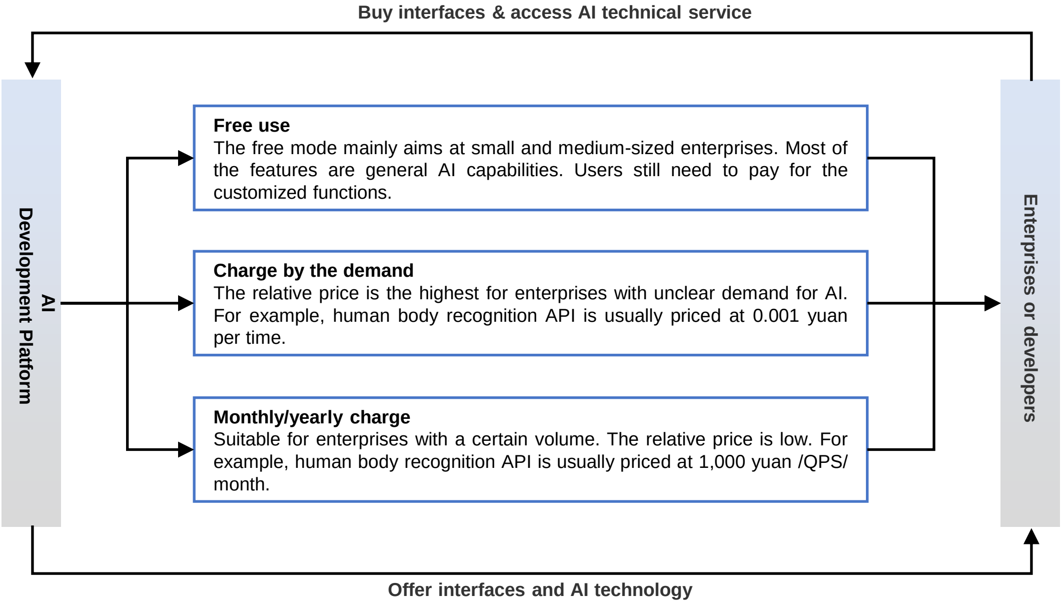
❑ AI development platform profits by providing companies or developers with AI technology interfaces or AI development tools. The billing methods mainly include free mode, billing based on pay-per-call billing, annual or monthly subscription. The free model provides companies or developers with commonly used and general AI technology interfaces such as text recognition and face recognition, with an upper limit of use, usually 1-5QPS/day. It is mainly prepared for small and medium-sized enterprises with small usage. The free model achieves profitability through data accumulation, building an AI ecosystem and providing additional services. Pay-per-call billing is also oriented to small and medium-sized enterprises. Compared with annual and monthly billing, pay-by-call billing is more expensive, which is suitable for companies that have not yet clear their demand.

❑ In terms of marketing, platform operators increase traffic conversion rates through free trials, subsidies, and online teaching. Large-scale platforms can further increase the conversion of traffic to users through permanent free general products. Platform operators can also explore other value-added needs of users in customer service, such as cloud services, customized AI development solutions, and so on.

❑ With the gradual expansion of scale, the average cost of a single customer of the AI development platform will decrease significantly, and the service profit margin will gradually increase. Therefore, achieving large-scale operations is an important development strategy for the AI development platform, which can help the platform reduce costs while also giving the platform more room for bargaining. This phenomenon also explains the underlying business logic that large manufacturers can still achieve profitability under the 'partial free' mode, and also reflects the market competitive advantages of large manufacturers compared to small and medium-sized manufacturers.

Source：Frost & Sullivan

AI development platform business mode


Buy interfaces & access AI technical service
AI Development Platform
Enterprises or developers
Offer interfaces and AI technology

Free use
The free mode mainly aims at small and medium-sized enterprises. Most of the features are general AI capabilities. Users still need to pay for the customized functions.

Charge by the demand
The relative price is the highest for enterprises with unclear demand for AI. For example, human body recognition API is usually priced at 0.001 yuan per time.

Monthly/yearly charge
Suitable for enterprises with a certain volume. The relative price is low. For example, human body recognition API is usually priced at 1,000 yuan /QPS/ month.

Source：Frost & Sullivan

Market Size

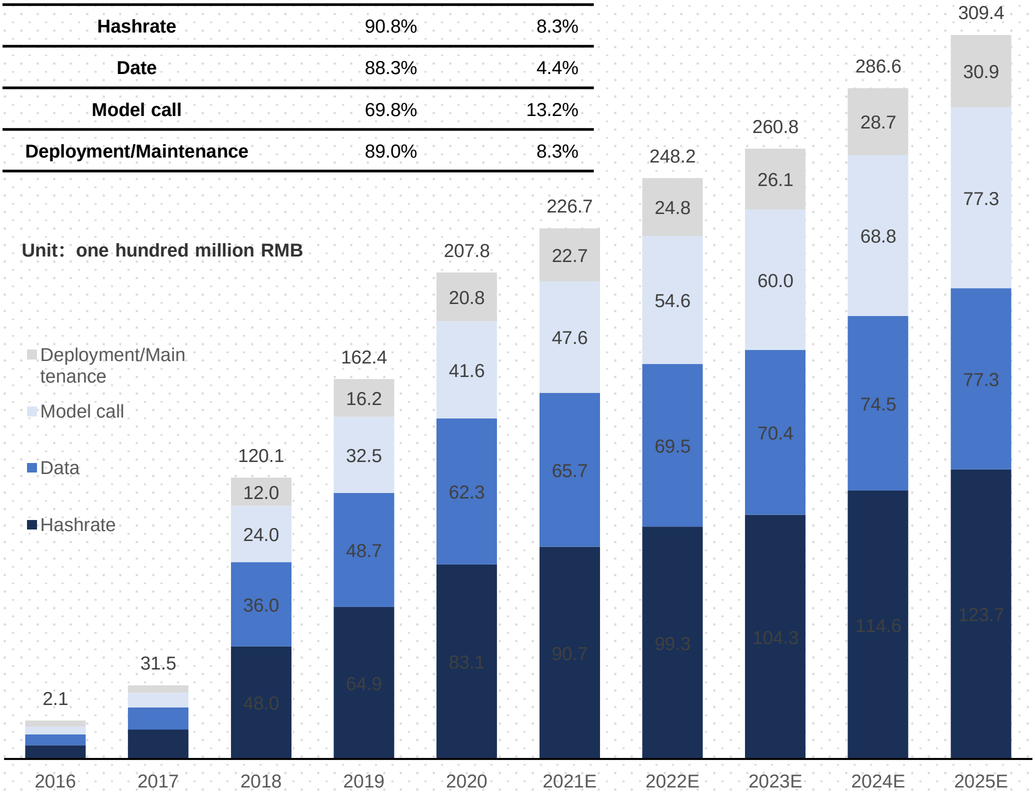
“The revenue of China's AI development platforms will exceed 20 billion yuan in 2020. The proportion of model call business revenue will increase.”

- ❑ From 2016 to 2020, the revenue scale of China's AI development platforms expanded rapidly. In 2020, the revenue of China's AI development platforms have exceeded 20 billion RMB.
- ❑ At present, computing power, data, model call and deployment/maintenance account for about 4:3:2:1 in the total revenue of the platform. The revenue share of data business is expected to decline as the share of inference applications increases. As AI becomes more widely used in vertical scenarios, the revenue share of model call business is expected to increase.

AI development platform market size（calculated by revenue），2016-2025 estimation

CAGR	2016-2020年	2020-2025年
Total	**88.9%**	**8.3%**
Hashrate	90.8%	8.3%
Date	88.3%	4.4%
Model call	69.8%	13.2%
Deployment/Maintenance	89.0%	8.3%

Unit：one hundred million RMB



Source：Frost & Sullivan

Chapter 3

Competitive factors: design a better platform for developers

Technology advances on supply side

Optimize developers’ experience in the demand side

Competitive Factors

“The core competition of the AI development platform will focus on ‘improving its own service supply capabilities’ and ‘meeting customer needs’”

- ❑ The users of the AI development platform are the developers of individuals or enterprises in the AI industry. The core competition of the AI development platform will revolve around how to provide developers with more efficient and convenient development platforms and other derivative services. Sullivan summarized the core competitiveness of the AI development platform as the hard power to "improve its own service supply" and the soft power to "meet customer needs".

AI development platform vendors rely on the capabilities of the underlying hardware and algorithm models of the platform to provide developers with more effective AI development platform services.

Hard power 1: Artificial Tagging——The difficult breakthrough from ‘Artificial’ to ‘Intelligence’

- ❑ The intelligent replacement of Data tagging is extremely difficult. At this stage, the tagging tool can complete basic tagging tasks with the help of algorithms, such as automatic frame recognition, automatic speech recognition, etc., and the algorithm of the tagging tool is constantly being developed and optimized.

- ❑ For AI development platforms, the intelligent labeling function is of great importance in terms of optimizing the efficiency of its own algorithms and optimizing user experience. The intelligent labeling functions that can be launched on the AI development platform include the introduction of GANs to optimize the labeling effect, the semi-supervised learning mechanism to solidify the labeling, and the introduction of a difficult case screening mechanism to optimize the labeling results and provide suggestions for improvement of data labeling based on difficult cases. However, in the actual application process, Manufacturers still need to address the limitations of the above methods.

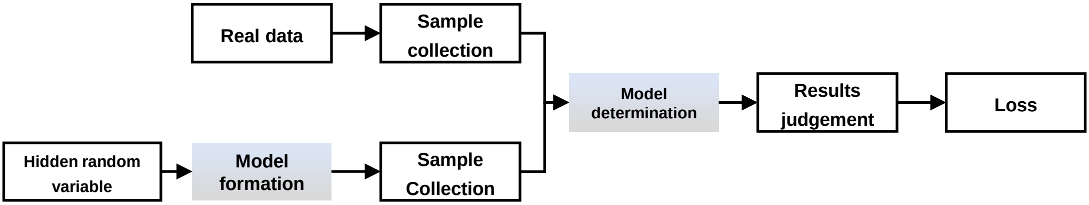
  - GANs: Generators and discriminators need high synchronization, but in actual training it is easy to produce discriminator convergence, generator divergence scenarios, the optimization of the discriminator and generator requires extremely high design standards; GANs in the training process There will be the problem of model missing, that is, the generator function is degraded, and the same sample points are continuously generated, which makes the learning process unable to continue.

  - Semi-supervised learning: It is difficult for the model to correct its own errors; excessive smoothing may occur, causing the characteristics of the nodes to be indistinguishable.

Source: aijishu, easyAI, Huawei Cloud, Frost & Sullivan

- Difficult case screening mechanism: Only difficult cases can be generated during the model training process, offline difficult case mining cannot be realized, and users must adaptively modify the code to use online difficult case mining; the core idea of the difficult case screening mechanism is through bootstrapping The method of (bootstrapping) generates a set of difficult examples, and the generation method is only judged by the loss value of the training sample during training. The evaluation dimension is single, and the improvement of model accuracy cannot be guaranteed; the algorithm idea is not mature enough to form a systematic plan.

Generative Adversarial Networks (GANs) algorithm flow chart



Hard power 2: Machine learning structure——Improve structural defects，improve users' experience，construct AI ecology

❑ TensorFlow and PyTorch are mainstream machine learning frameworks, with a large developer community and a large amount of mature code available. These two account for more than 90% of the global deep learning framework. But TensorFlow and PyTorch have different characteristics from each other:

TensorFlow:

- **Advantage:** It is suitable for industrial production environments, with complete solutions for model training and deployment.
- **Disadvantage:** There are many different styles of API, which are not friendly to novices. The iterative idea of distributed training is not clear. The support for cloud native is low.

PyTorch:

- **Advantage:** The programming API style is simple, intuitive and easy to understand.The built of a deep learning model based on dynamic calculation graphs can quickly debug according to stack information.
- **Disadvantage:** The deployment ecology is still in the growth stage. Some operations are not supported.

Source: aijishu, easyAI, Huawei Cloud, AI Platform Construction, Frost & Sullivan

❑ Manufacturers such as Baidu and Huawei have launched machine learning self-developed frameworks PaddlePaddle and MindSpore.

PaddlePaddle：

- **Advantage:** Active community, complete ecological chain, user-friendly applications, full-process capability support, fast iteration pace, and support for large-scale asynchronous distributed training.
- **Disadvantage:** Most of the users are individual developers. It is not yet widely used by vendors.

MindSpore：

- **Advantage:** Supports enhanced visualization function, differential privacy, second-order optimization algorithm, graph neural network, quantitative training, hybrid heterogeneous, MindSpore Serving, PS distributed training, MindIR, debugger, etc. Supports multiple platforms. Advocates for software and hardware collaborative design. Supports multiple modes of distributed training, etc.
- **Disadvantage:** The number of people in the community is small. Some functions still need to be improved.

❑ The limited number of developers is a unified defect of the open source machine learning framework of Chinese manufacturers. There is a significant gap in the number of users compared with TensorFlow and PyTorch, and only Chinese and English are supported in language support capabilities. In contrast, TensorFlow and PyTorch will support some minority languages. So its developer ecology is more complete.

❑ At present, the global machine learning framework ecology is basically stable. The common frameworks TensorFlow and PyTorch have been open sourced early, so they have ecological advantages. The self-developed framework of Chinese manufacturers can optimize the framework architecture through its technical iteration of machine learning and learning from the defects of TensorFlow and PyTorch. The research framework can provide developers with a better experience. In the long run, the developer ecology of China's self-research framework is mostly concentrated in China. In the future, more companies will use China's self-research ecology for machine learning development. However, the global machine learning framework is still expected to be led by TensorFlow and PyTorch.

Source: AI Platform Construction, Frost & Sullivan

Hard power 3: Pre-training model——Both 'large' and 'small'

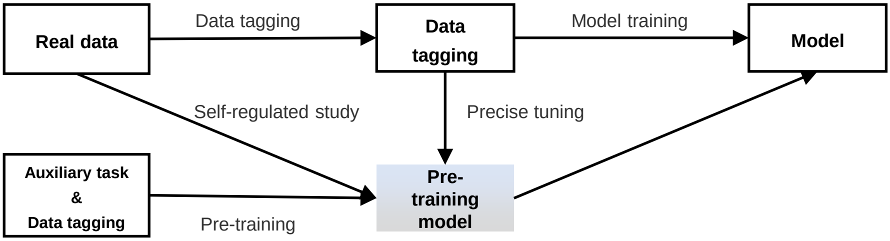
- ❑ In the future, AI development platform vendors will release multiple pre-training models that support computer vision, speech recognition, speech synthesis, natural language processing, machine translation, intelligent recommendation, business analysis and prediction, scientific computing, multi-modal data tasks and composite tasks . The pre-training model will also develop along a multi-technology path.

  - The scale of the pre-training model will increase ('large'): the large-scale pre-training model will include more than 100 billion parameters, and the cost of a single training is expected to exceed 10 million U.S. dollars. Therefore, the pre-training model will be equipped with training optimization techniques including mixed precision training, data parallelism, model parallelism, Lamb optimizer, three-dimensional parallel training, and sparse attention acceleration. But this kind of pre-training model process is cumbersome and can only be deployed in cloud applications.

  - The pre-trained model will improve its flexibility ('small') through compression and acceleration: compression based on pre-trained language models such as knowledge distillation and pruning, or compression through matrix parameter decomposition, parameter sharing, and model structure design and search. Remove the redundant part of the parameter matrix and make the model "small". Or quantization-based pre-training language model compression, reducing the bit value required for numerical representation, such as quantizing a 32-bit floating point number calculation into an 8-bit or even 4-bit floating point number, simplifying the calculation process. The compressed pre-training model can be applied to the device side, and the application value is extremely wide.

- ❑ In the future, AI development platform vendors need to continuously optimize the original training methods, accelerate the training speed for training models such as Resnet50-v1.5, SSD-ResNet34, 3D UNET, RNNT, Openpose, YOLO, BERT, DLRM, etc. Or propose new training methods and improve the maturity of the pre-training model.

Pretraining model conceptual graph



Source: AI Platform Construction, Frost & Sullivan

AI development platform vendors improve the developers' platform using experience by providing flexible services and simplifying the operating procedures of developers. It aims to build vendors soft competitiveness.

Soft power 1: AutoML——Lowering AI development barrier, enhancing AI development efficiency

- ❑ AutoML is one of the important trends in the field of artificial intelligence. AutoML will be able to integrate the iterative process into traditional machine learning to build an automated process and greatly reduce the threshold of machine learning: AutoML is a machine learning process that uses a series of algorithms and heuristics to achieve from data selection to modeling automation. Researchers only need to input meta-knowledge (convolution operation process/problem description, etc.), and the algorithm can automatically select the appropriate data, automatically optimize the model structure and configuration, automatically train the model and adapt it to be deployed to different devices.

- ❑ AutoML can help AI development platforms to automatically complete tasks such as neural structure search, model selection, feature engineering, hyperparameter tuning, and model compression. Classification or regression problems that rely on structured or semi-structured data can be automated through AutoML, which greatly improves the efficiency of AI training.

- ❑ However, there are still some difficulties to be solved in the development path of AutoML. Firstly, AutoML still needs a lot of computing power, and companies still need to try more solutions in the research and development process. Secondly, AutoML needs to maintain a certain degree of transparency while increasing the processing complexity to allow users of the model to confirm the quality of the model. As an automation tool, AutoML has limitations in terms of resource optimization and iteration, complex model processing andfeature engineering while improving work efficiency.

Soft power 2: Developers centered——Enhancing platform service capacity to built an ecosystem

- ❑ The AI development platform is a service for developers. The ability of the platform to meet the needs of developers, improve platform compatibility, and provide developers with a better development experience should also become an important evaluation criterion.

  - **In terms of data preparation functions,** the AI development platform can provide multiple data access methods including local data set loading, third-party open-source data set loading, and cloud data set calling. The platform can also provide multiple types of data annotation service models. It can also visualize the data on the operation panel.

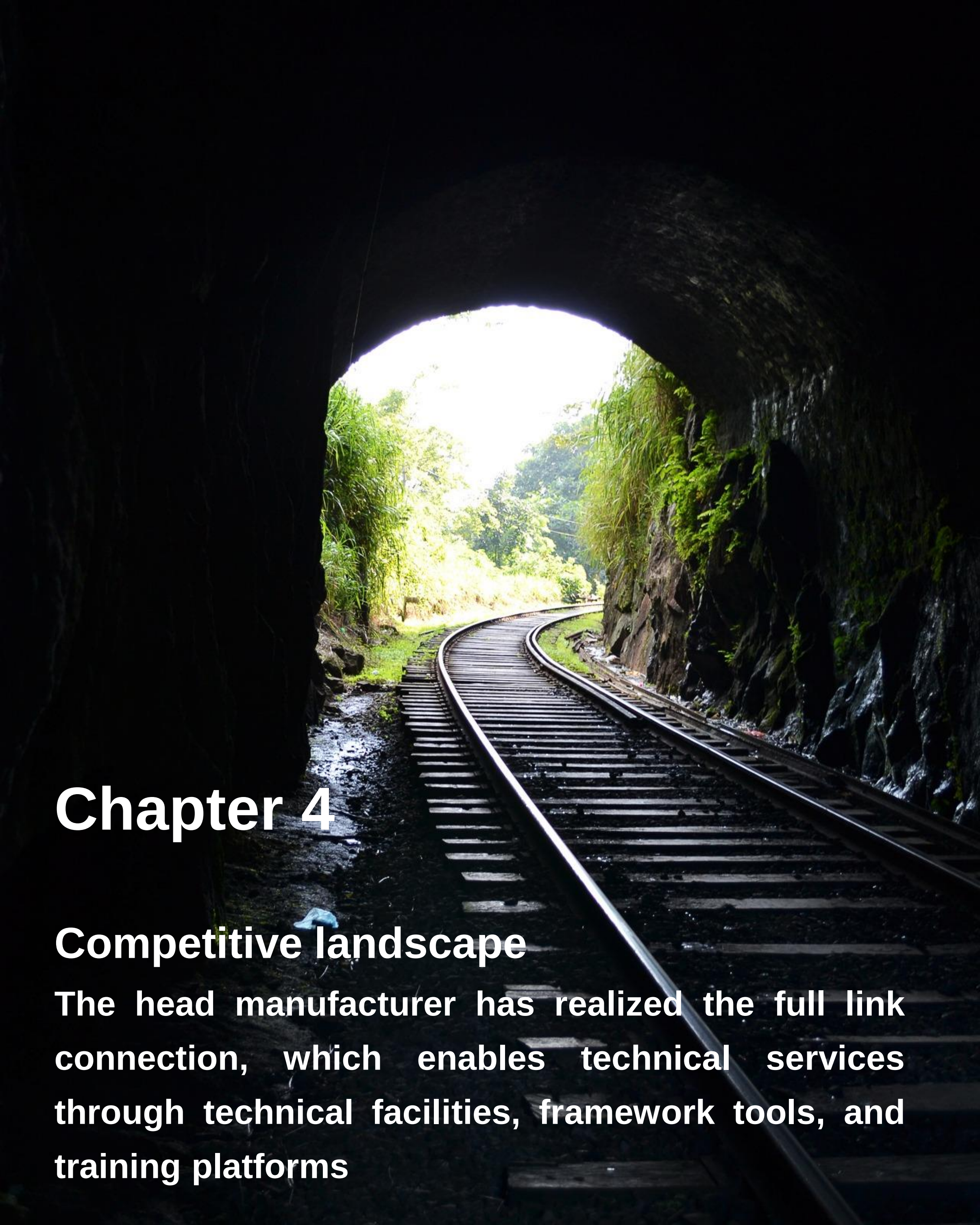
Source: Huawei, Frost & Sullivan

- **In terms of model training functions,** the AI development platform can improve the compatibility of machine learning frameworks, programming languages, and cloud IDE tools. It provides customized and modular algorithm modification methods. At this stage, mainstream AI development platforms can support model management services such as flexible training, real-time monitoring of computing resources, heterogeneous training of hardware devices, multiple parallel training modes, and pre-training model migration, providing developers with convenient AI development services.

- **In terms of model management and deployment functions,** the AI development platform research and development direction covers the provision of improving the compatibility of the AI development platform, such as supporting more programming languages, supporting CI/CD, supporting third-party AIOps tools, and supporting users to build their own workflows. Machine learning workflow construction services, support model deployment monitoring services, including model drift monitoring, resource load monitoring, automatic alarms, and visual presentation of monitoring indicators.

- **In terms of account management function service capabilities,** some mainstream AI development platforms choose to open some free resources such as computing resources, storage resources, data set resources, model resources, etc., to provide developers with platform experience services. Most AI development platforms provide multiple charging modes including payment, prepayment, subscription payment (such as annual fee and monthly fee). These solutions managed to enhance the flexibility of platform fees and meet the needs of different types of developers.

Source: Huawei, Frost & Sullivan



Chapter 4

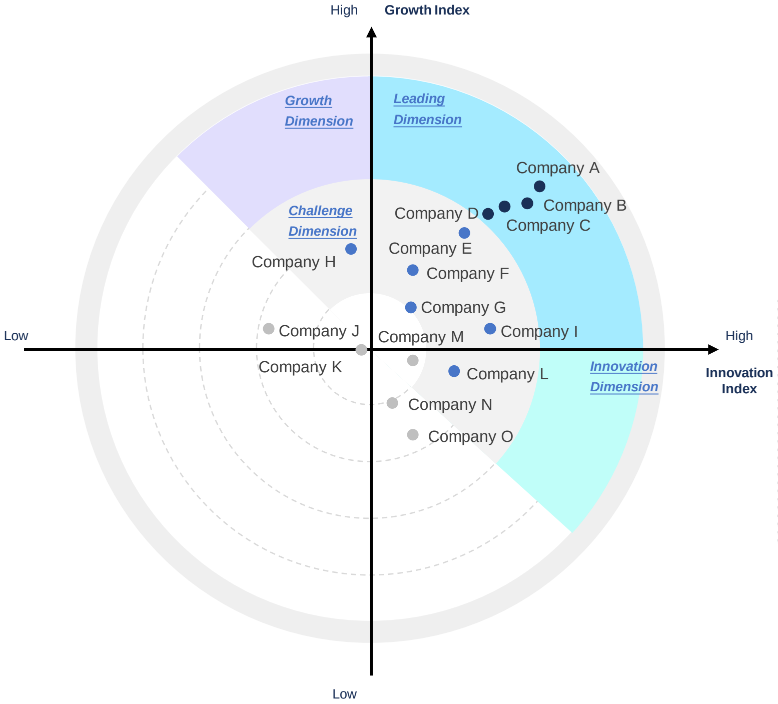
Competitive landscape

The head manufacturer has realized the full link connection, which enables technical services through technical facilities, framework tools, and training platforms

Overall Performance

> “The AI development platform market in China is in the stage of technological maturation and platform improvements. Competitors in the AI development platform market have competitive advantages in their innovation and growth ability.”

Comprehensive competitive performance of AI development platform in China——Frost Radar™



Note: The circle's growth from inside to outside corresponds to the comprehensive score from low to high. The competitiveness is synthesized by the 'innovation index' and 'growth index'.

The AI development platform application market in China is growing steadily. Our analysis result is only applicable to the current stage of this market.

Sullivan will continue to focus on the market of AI development platform and capture the competition trend.

❑ **The horizontal axis represents 'innovation index':**

- It measures the innovation ability of competitors in the AI development platform market. Large abscissa represents rich service functions and strong product tuning ability.

❑ **The vertical axis represents 'growth index':**

- It measures the competitiveness of competitors in the fields of product structure, product function and the performance growth. High ordinate represents high growth capacity of its AI development platform product.

Source: Sullivan Data

Scoring Dimensions

> “This report assessed and analyzed AI develop platform based on the innovation rate assessing system. Technology innovation and service innovation are two components being assessed.”

AI Development Platform in China: Scoring dimension——Innovation index

	1st level index	2nd level index	Key points
Innovation Index	Technology innovation	Basic infrastructure	Assess performance in AI chips and the development and innovation of AI server etc.
		Data collection and label	Assess performance in intelligence data collection, label, analysis, filtration, enhancement etc.
		Bottom framework	Assess performance in the innovation of AI deep learning structure etc.
		Algorithm model	Assess performance of AI algorithm model in correctness, efficiency and universality of scenes etc.
	Service innovation	Cloud-native structure	Assess performance of AI develop platform in the practice of cloud-native structure, optimization of cloud computing resource and optimization of cloud develop environment etc.
		Cloud security governance	Assess performance of AI develop platform in the practice of cloud security technology and the ability of enhancing the overall platform security etc.
		Big data management	Assess performance of AI develop platform in the practice of big data management and the ability of enhancing the value of platform’s database etc.
		Visual development	Assess performance of AI develop platform’s ability in visualization, 0 entry barrier development functional elements, simplification of developing procedure and the ability of lowing develop barrier etc.

Source: Sullivan Data

Scoring Dimensions

“This report assessed and analyzed AI develop platform based on the innovation rate assessing system. Service and ecosystem are two components being assessed.”

AI Development Platform in China: Scoring dimension——Growth index

	1st level index	2nd level index	Key points
Growth Index	Service	Computing service	Assess the computing performance of AI develop platform in its size, deployment and management etc.
		Data service	Assess the performance of AI develop platform in data sample size, product compatibility and product diversity etc.
		Algorithm service	Assess performance of AI develop platform in the compatibility of deep learning structure and the diversity, compatibility and portability of algorithm model product etc.
		Platform service	Assess performance of AI develop platform in data security and management, AI develop management and AI deployment etc.
		Pricing strategy	Assess performance of AI develop platform in the flexibility of service pricing and charging etc.
	Ecosystem	Ecological prosperity	Assess performance of AI develop platform in the prosperity of its development community, market influence and application range etc.
		Ecological development	Assess performance of AI develop platform in sustainable growth and the self-defense ability towards external threats etc.

Source: Sullivan Data

Terms

- **QPS (Queries per-second):** QPS is a measure of how much traffic is being processed by a particular query server in a given period of time, which can be understood as the number of concurrent requests per second. One QPS is equal to 86,400 calls approximately.
- **API (Application Programming Interface):** APIs are predefined functions designed to provide applications and developers with the ability to access a set of routines based on a piece of software or hardware without having to access the source code or understand the details of the inner workings.
- **Convolution:** The mathematical concept of generating a third function from two functions f and g, representing the integral of the overlapping length of f and g by the product of the overlapping values flipped and shifted.
- **CGRA (Coarse-grained Reconfigurable Architecture):** CGRA is a spatial parallel computing model, which organizes computing resources with different granularity and functions by spatial hardware structure. During operation, according to the characteristics of data flow, the configured hardware resources are interconnected to form a relatively fixed computing path, and the way of computing is close to "special circuit". When the algorithm and application transform, again through configuration, reconfiguration for different computational paths to perform different tasks.
- **CUDA (Compute Unified Device Architecture):** CUDA is a parallel computing platform and programming model created by NVIDIA based on Graphics Processing Units (GPUs) produced by NVIDIA.
- **DevOps:** A combination of Development and Operations, DevOps is a collective term for a group of processes, methods, and systems that facilitate communication, collaboration, and integration between Development (application/software engineering), technical Operations, and quality assurance (QA) departments.
- **Data tagging:** The process of tagging metadata such as text, video, and images. The labeled data will be used to train machine learning models.
- **Cloud native:** distributed cloud based on distributed deployment and unified management, a set of cloud technology product system based on container, microservice, DevOps and other technologies.

Methodology

- Frost & Sullivan has conducted in-depth research on the market changes of 10 major industries and 54 vertical industries in China with more than 500,000 industry research samples accumulated and more than 10,000 independent research and consulting projects completed.

- Rooted on the active economic environment in China, the research institute, starting from data management and big data fields, covers the development of the industry cycle, follows from the enterprises' establishment, development, expansion, IPO and maturation. Research analysts of the institute continuously explore and evaluate the vagaries of the industrial development model, enterprise business and operation model, Interpret the evolution of the industry from a professional perspective.

- Research institute integrates the traditional and new research methods, adopts the use of self-developed algorithms, excavates the logic behind the quantitative data with the big data across industries and diversified research methods, analyses the views behind the qualitative content, describes the present situation of the industry objectively and authentically, predicts the trend of the development of industry prospectively. Every research report includes a complete presentation of the past, present and future of the industry.

- Research institute pays close attention to the latest trends of industry development. The report content and data will be updated and optimized continuously with the development of the industry, technological innovation, changes in the competitive landscape, promulgations of policies and regulations, and in-depth market research.

- Adhering to the purpose of research with originality and tenacity, the research institute analyses the industry from the perspective of strategy and reads the industry from the perspective of execution, so as to provide worthy research reports for the report readers of each industry.

Legal Disclaimer

- The copyright of this report belongs to LeadLeo. Without written permission, no organization or individual may reproduce, reproduce, publish or quote this report in any form. If the report is to be quoted or published with the permission of LeadLeo, it should be used within the permitted scope, and the source should be given as "LeadLeo Research Institute", also the report should not be quoted, deleted or modified in any way contrary to the original intention.

- The analysts in this report are of professional research capabilities and ensure that the data in the report are from legal and compliance channels. The opinions and data analysis are based on the analysts' objective understanding of the industry. This report is not subject to any third party's instruction or influence.

- The views or information contained in this report are for reference only and do not constitute any investment recommendations. This report is issued only as permitted by the relevant laws and is issued only for information purposes and does not constitute any advertisement. If permitted by law, LeadLeo may provide or seek to provide relevant services such as investment, financing or consulting for the enterprises mentioned in the report. The value, price and investment income of the company or investment subject referred to in this report will vary from time to time.

- Some of the information in this report is derived from publicly available sources, and LeadLeo makes no warranties as to the accuracy, completeness or reliability of such information. The information, opinions and speculations contained herein only reflect the judgment of the analysts of leopard at the first date of publication of this report. The descriptions in previous reports should not be taken as the basis for future performance. At different times, the LeadLeo may issue reports and articles that are inconsistent with the information, opinions and conjectures contained herein. LeadLeo does not guarantee that the information contained in this report is kept up to date. At the same time, the information contained in this report may be modified by LeadLeo without notice, and readers should pay their own attention to the corresponding updates or modifications. Any organization or individual shall be responsible for all activities carried out by it using the data, analysis, research, part or all of the contents of this report and shall be liable for any loss or injury caused by such activities.