

Patent Analysis of International Speech Synthesis Technology

Ye Yuan, Jiaqi Zeng, Jiming Liu

School of Economics and Management, Chongqing University of Posts and Telecommunications, Chongqing 400065, China.

Abstract

[Purpose/Significance] With the breakthrough of 5G communication technology, we are going to enter an era of Internet of things. **[Method/Process]** Based on the global patent database of Patsnap, this paper studies the current situation of speech synthesis technology from the perspective of patent analysis. **[Results/Conclusion]** According to the analysis, speech synthesis technology is in a rapid development stage; the current research hot areas are G06F17 and G06K9; Chinese patentees are small and scattered; the United States is the first in influence and patent quality, and there is a certain gap between China and it; China has the world's largest number of patent applications, which belongs to the technology activist; Chinese enterprises do not pay attention to the overseas market layout.

Keywords

Speech synthesis; Patent analysis; Technology.

1. Introduction

With the advent of the era of artificial intelligence, intelligent voice technology has received unprecedented attention and development, and speech synthesis technology, which is one of the three major technologies of intelligent voice, has also become a field competed by various technology giants, such as iFLYTEK, Baidu, Tencent, etc. Well-known companies have provided their own speech synthesis platforms, such as Baidu AI open platform and Xunfei open platform.

Patent is an important result of technological development and an important carrier of technical information^[1]; with the continuous improvement of the patent database; patent information has been widely used in competitor analysis, value chain analysis, and prevention of infringement risks. Wang Jiang^[2]; Found through analysis; China has a large number of patent applications in the field of smart finance, but the company's competitiveness is weak, financial institutions mainly complete the transformation by purchasing services and technology M&A(merge and acquisition); and suggest that basic research and deep application in the field of smart finance in China should be parallel, in key areas, develop patents in advance in advantageous areas, at the same time strengthen financial institutions, technology enterprise, multi-party cooperation of new fintech companies; Ge Huilei^[3], Through patent research on the satellite navigation industry, it is concluded that my country's satellite navigation industry has obvious advantages in innovation in some technical fields, but basic technology research is still insufficient, At the same time, the external representation of the industrial patent jungle began to emerge. Simultaneously; many studies carry out empirical research through patent data. Shao Peizhang^[4], believe that there is a significant positive correlation between the level of economic development and the amount of patent acceptance and authorization; and affirmed the significance of the third revision of the Patent Law; Mao Hao; Chen Da Peng; Yin Zhi Feng^[5], it is found that the two types of protection modes of judicial and administrative law enforcement generally show significant complementary effects in the process of innovation and incentive, When the growth

of administrative law enforcement fails to effectively supplement judicial protection, the innovative incentive effect of the dual-track system will also be significantly reduced.

By combing the existing literature, this article finds that in the existing research, there are few patent synthesis and literature information analysis of speech synthesis technology, only two; One is Nurbuli's^[6] "A Quantitative Analysis of the Research Status and Development Trend of Speech Synthesis Technology"; The author uses citespace to analyze the literature in the field of speech synthesis in the past 20 years, and proposes that neural networks are becoming an emerging technology in the field of speech synthesis; The other one is Cui Xintong^[7] article titled "Speech Analysis of Patent for Speech Synthesis Technology" published in "Electronic Technology and Software Engineering"; Introduced the general overview of the current speech synthesis field, but did not make an in-depth mining of patent information. This article is based on wisdom bud patent data, and has influence on current research hotspots and patent influence; Perform statistical analysis on patent quality and overseas distribution of patents to provide a basis for decision-making for the development of my country's speech synthesis technology.

2. Data Sources

Patsnap(Wisdom Bud) is a global patent search database that contains patent information from 109 countries and regions around the world from 1970 to the present; it is a comprehensive database that comprehensively reflects world patent information. Through the relevant literatures' ^[8] ^[9] ^[10] organization and comprehensive expert opinions; determine the speech synthesis keywords, and finally refer to IPC to determine its IPC classification number, and finally get the search formula. The search formula of this article in the wisdom bud patent database is: (TA_ALL:(Text To Speech OR vocoder OR synthetic speech OR sound synthesis OR synthetic language OR parametric OR parameter OR Formant Synth OR Formant synthesis OR Linear Prediction Coding OR Levenberg-Marquardt Algorithm OR LPC OR Pitch Synchronous Overlap and Add OR PSOLA OR trained OR Hidden Markov Model OR HMM OR acoustic OR statistica)) AND IPC:(G10L OR G06Q OR G06F OR H04M OR G08B OR G06K OR HO4L). The retrieval time is February 6, 2020. According to the search formula, 319340 initial patent data were obtained. Because some patents will be applied in multiple countries, the same patents in these countries will form a simple family, so the patents are deduplicated according to simple identical groups. Patents usually have a postponement, in order to ensure accuracy, the data for 2019 and 2020 were cleared, and 162090 simple sibling representatives were finally obtained.

3. Industry-wide analysis

3.1 Patent application trends

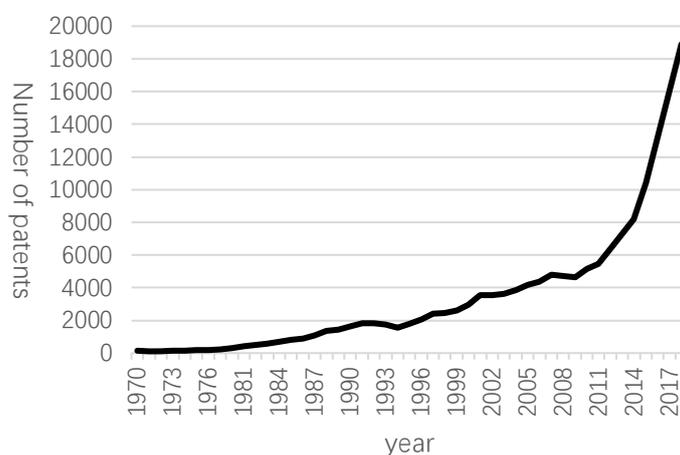


Figure 1 Global speech synthesis patent development trend

The development trend of patents in the field of global speech synthesis is shown in Figure 1.

It can be seen that from 1970 to 2018, the number of global speech synthesis patent applications has maintained an increasing trend; only in 1992-1994 and 2001-2002, the number of patent applications declined briefly; the reason may be that it was affected by the Bosnian War and the 9/11 incident, but then it has entered a stage of rapid growth, especially after 2014, with the commercialization of 4G networks and the development of information technology such as the Internet of Things, the average annual growth for five years The rate reached 23%. With the continuous development of 5G technology, it can be predicted that the number of patent applications in the field of speech synthesis will continue to grow in the future.

3.2 Analysis of hot technical fields

Table 1 Major IPC groups in the field of speech synthesis (top ten)

IPC group	Classification number explanation	Number of patents of the same family
G06F17	Digital computing or data processing equipment or method	32197
G06K9	For reading or recognizing printed or written characters or for recognizing graphics	16864
G06F3	Input device for converting data to be processed into a form that can be processed by a computer; output device for transferring data from a processing machine to an output device	14452
G05B19	Program control system	12149
G10L15	Speech Recognition	9757
G06F15	General digital computer; general data processing equipment	9242
G06F19	Apparatus or method specially suitable for digital calculation or data processing of specific applications	9018
G06F9	Program control design	8624
H04M1	Branch equipment	8016
G06Q50	Especially suitable for systems or methods in specific business fields	7615

In order to understand the main technologies in the field of speech synthesis, this paper analyzes the major IPC groups in the field of speech synthesis. It can be seen from Table 1; the main technology in the field of speech synthesis is focused on G06F (Electronic Digital Processing), G06K (data identification; record carrier), G05B (control or regulation system), G10L (speech analysis or synthesis; speech or voice recognition; pilot or speech decoding or coding), H04M (telephone communication), G06Q (data processing system or method). In order to analyze the hot technical fields in the field of speech synthesis; this paper analyzes the IPC growth trend in recent years with a fixed-base growth rate; since all the IPC large group of patents in 1998 were less than 500 and did not differ much, the number of patents in 1998 was selected as the fixed base value, and the formula is as shown in. According to the results, the top five IPC groups with fixed base growth rates in the past three years have drawn a trend chart of patent applications for the past two decades (Figure 2). After analysis, it was found that in 1998, the number of patent applications for G06F17, G06K9, G10L15, G06Q50, G10LQ10 were all below 500; from 1999 to 2014, although the number of patent applications in the G06F17 field has risen and fallen, the overall trend is rising, and the number of

patent applications in the five IPC groups has always maintained the first place, while the other IPC group patents are growing and There is little difference in quantity; from 2014 to 2018, the number of patents in the G06K9 field has sprung up, not only surpassing G06F17 in growth rate, but also the number of patent applications in 2018. Comprehensive analysis of the number of patent applications and their growth rate can be found that G06F17 and G06K9, which are the top two in the total number of patent applications and the growth rate of patent base, are recent hot research fields.

$$G_{(i,i+1)}=(H_{i+1}-H_i)/H_a \tag{1}$$

Among them; $G_{(i,i+1)}$ is the fixed growth rate from year i to year $i+1$; H_{i+1} is the number of patents in year $i+1$; H_i is the number of patents in year i ; H_a is the first The number of patents in a year is a fixed base value.

Table 2 IPC group fixed base growth rate (part)

Period IPCgroup	1998-1999	1999-2000	...	2015-2016	2016-2017	2017-2018
G06F17	10.28%	41.82%	...	215.19%	212.38%	95.56%
G06K9	34.92%	-12.70%	...	511.11%	976.19%	1421.43%
G06F3	-4.28%	28.79%	...	84.82%	-11.28%	-68.87%
G05B19	-9.48%	16.19%	...	9.70%	11.79%	-16.15%
...
H04M1	18.10%	-12.38%	...	34.29%	33.33%	-58.10%
G06F19	-8.13%	36.88%	...	20.63%	-68.13%	-272.50%

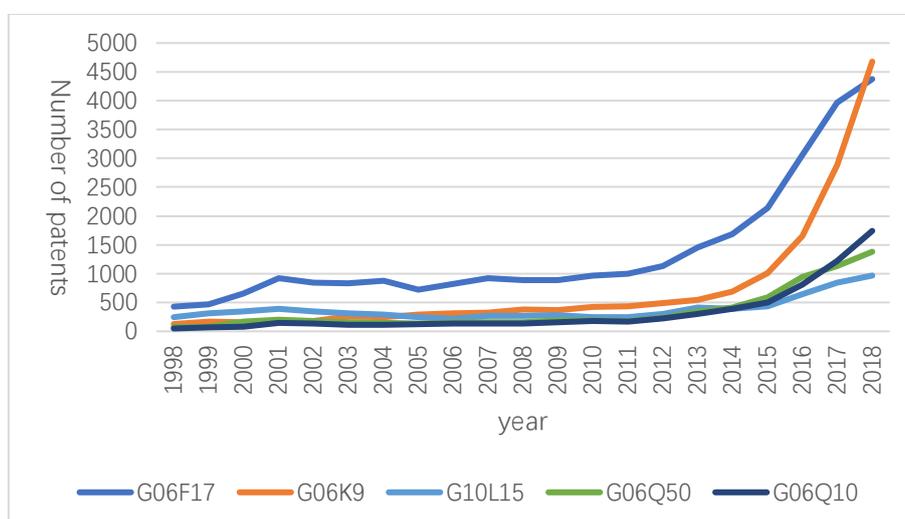


Figure 2 The top five IPC group's patent application trends over the past 20 years

4. Analysis of major competing countries

4.1 Determination of main competing countries

This article counts the number of patents in the country or region where the patentee of each patent belongs (see Table 3). Patents in the field of speech synthesis are distributed in 25 countries and regions. The top ten countries and regions for patent occupancy include China, the United States, Japan, Germany, South Korea, Taiwan, France, the Netherlands, the United Kingdom, and Russia. Among them, mainland China, the United States, Japan and Germany have a patent share of 73.77%, making them a strong competitor in the field of speech synthesis.

Table 3 The main distribution countries of patentees of speech synthesis

Serial number	country	Number of patents	proportion	Cumulative percentage
1	China	58276	35.95%	35.95%
2	USA	28047	17.30%	53.26%
3	Japan	26357	16.26%	69.52%
4	German	6887	4.25%	73.77%
5	Korea	5882	3.63%	77.39%
6	Taiwan	3231	1.99%	79.39%
7	France	2257	1.39%	80.78%
8	Netherlands	1468	0.91%	81.69%
9	UK	1270	0.78%	82.47%
10	Russia	1161	0.72%	83.19%

4.2 Analysis of the influence of major competing countries

The H index was originally an indicator proposed by an American physicist in 2005 and used to measure the achievements of researchers^[11]; it was later introduced into literature measurement and patent analysis. The larger the H value, the greater the influence of the literature or patents representing the R&D institution and the stronger the competitiveness. Then, Ravallion et al. proposed a secondary influence index based on the H index^[12]. Most technologies are developed from existing technologies, so the higher the frequency of citations of a patent, the higher its influence and the higher the influence of the patent R&D institution. Bring the cited frequency of the patent into the secondary influence index formula (see formula 2).

$$H_j = (\sum(2 - e_i/e_{max})(e_i/e_{max})\frac{1}{a_j}) \quad (2)$$

Among them; H_j represents the secondary index of influence in country j ; e_{max} represents the highest cited frequency of individual patents in country j ; e_i represents the cited frequency of the i -th patent; a_j represents the total number of patents owned in country j .

Table 4 Secondary index of influence of major countries

Secondary influence index	USA	Japan	German	China
	1	0.683	0.845	0.808

The quadratic index of influence of the four main competing countries is normalized as shown in Table 4. Among the four main competing countries, the United States has the highest secondary index value, indicating that it has the most influence, and its inventions are mostly major inventions that have a greater impact in the field of speech synthesis; Japan's influence is the smallest of the four countries, indicating that Japan is dominated by small and medium-sized patents.

4.3 Analysis of main patentees

The top fifteen patentees with the largest number of patents in the field of international speech synthesis are shown in Table 5. Nine of them are from Japan, ranking first, third, fourth, fifth, sixth, seventh, eighth, tenth, and fourteenth; two from the United States ranked second and tenth respectively; two from China, ranked thirteenth and fifteenth; one from South Korea ranked eleventh; the remaining one from Germany ranked ninth. Among them, the top 15 Japanese companies account for 62% of Japanese patents; while the top 15 Chinese companies account for only 1.8% of the country's total.

Table 5 Main patentees in the field of speech synthesis

Rank	patentee(英)	专利权人(中)	country	Number of patents
1	NEC	日本电器公司	日本	2762
2	IBM	国际机器商业公司	美国	2273
3	TOSHIBA	东芝	日本	2156
4	HITACHI	日立	日本	1894
5	PANASONIC	松下	日本	1826
6	FUJITSU	富士通	日本	1815
7	NIPPON TELEGRAPH AND TELEPHONE	日本电报电话公司	日本	1715
8	CANON KAUSHIKI KAISHA	佳能	日本	1584
9	SIEMENS	西门子	德国	1467
10	MITSUBISHI ELECTRIC	三菱	日本	1407
11	SAMSUNG ELECTRONICS	三星电子	韩国	1406
12	MICROSOFT TECH LICENSING	微软	美国	1323
13	STATE GRID CORPORATION OF CHINA	国家电网有限公司	中国	1248
14	SONY	索尼	日本	1198
15	LENOVO	联想	中国	1032

4.4 Comprehensive competitive strength analysis

In order to more comprehensively evaluate the comprehensive competitive strength of each major country, this paper uses the patent portfolio index calculation method^[13] to calculate the comprehensive strength of the four major competing countries, and is divided into technology leaders,

potential competitors, technology activists and Technology laggards. The main calculation formula is shown in formula 3 and formula 4.

$$PA_iF = N_i / N_a \tag{3}$$

$$PQ_iF = Q_1 + Q_2 + Q_3 \tag{4}$$

Among them, PA_iF is the patent activity index, N_i is the number of patent applications in country i , N_a is the average number of patent applications in four countries; PQ_iF is the patent quality index in country i , Q_1 is the range of patent technology, Q_2 is the international range of patents, Q_3 is the citation Frequency relative index value.

Table 6 Calculation results of patent indexes of main competing countries

country \ index	Japan	USA	China	German
PA _i F	0.45228	0.48128	1	0.11818
PQ _i F	0.51387	1	0.5879	0.5181

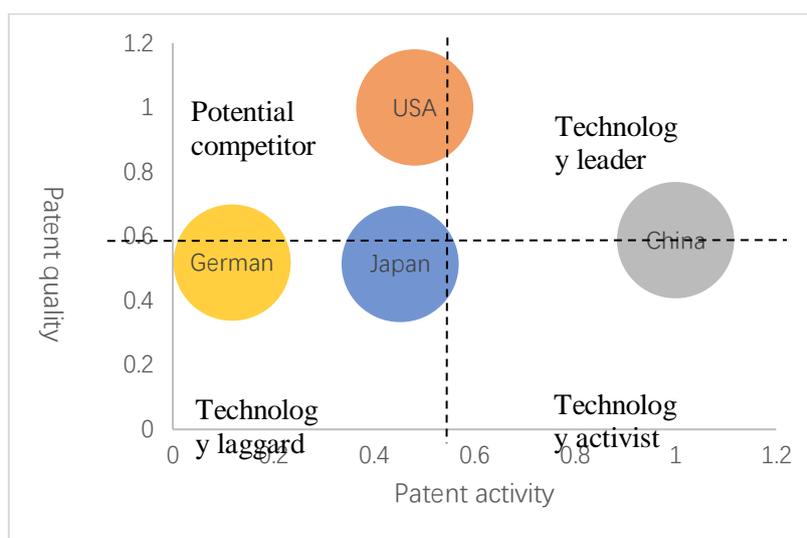


Figure 3 Technology classification of main competing countries

After calculating the results, in order to be able to more intuitively see the differences between countries, we standardized the index values in patent activities and patent quality. The results are shown in Table 6. It can be seen that in the field of speech synthesis, both Germany and Japan are technological laggards. Although Japan’s patent activity is higher than that of Germany, its patent quality is not much different from that of Germany; although the United States is inferior to China in patent activities and ranks second, its patent quality is the highest, nearly double that of China with the second highest patent quality. Its development potential cannot be underestimated and it belongs to potential competitors; although China is a technology activist and still has a certain gap with the United States, it is on the edge of technology leaders and technology activists and is developing towards technology leaders. Therefore, China has good prospects for development.

4.5 Analysis of overseas patent layout

The same family of patents is due to the regional nature of patent protection. Patent applications for the same invention and creation need to be approved by different patent management agencies to

obtain protection in different regions. The patent approval system is different from each management agency, resulting in a multi-level distribution of patents. Set of patent documents. Therefore, the overseas layout information can be obtained from the patent family information, so as to see the importance of the main competing countries to other countries' markets. This article first counts the patent layout of the main competing countries (Table 7) and uses Formula 5 to calculate its overseas distribution ratio^[14]; the calculation results are shown in Table 8.

$$ODR_i = \frac{\sum P_{i-j}}{P_i} \tag{5}$$

Among them, ODR_i is the overseas distribution rate of country i ; P_{i-j} is the number of patents of country i in country j , P_i is the total number of patents of country i .

Table 7 Patent layout of major competing countries

Patent importing country \ Patent exporting country	USA	Japan	German	China	Korea	India	Europe
USA	26917	7012	3835	6701	3835	2684	9300
Japan	8923	25516	1776	3417	1776	388	3477
German	3325	1381	5116	1718	773	669	3228
China	2091	498	438	57933	400	364	891

Table 8 Overseas distribution ratio of major competing countries

Overseas distribution rate	USA	Japan	German	China
	261.56%	102.41%	328.44%	16.45%

It can be seen that Germany has the highest overseas distribution rate, and its main distribution countries are the United States and Europe; the United States has the second highest overseas distribution rate, and its main distribution countries are Europe and Japan; Japan ranked third, the main layout country is the United States; and China's overseas distribution rate is the lowest, only 16.45%, indicating that its patents are mainly for the domestic market, and the level of internationalization is not high.

5. Research conclusions and recommendations

(1)Speech synthesis originated before 1970 and is currently in a period of rapid development, and will be a hot research field in the future. China should seize the opportunity to deepen the layout of the speech synthesis field and accelerate the development of speech synthesis technology, especially in the two hot areas of G06F17 and G06K9, we must increase investment to ensure that it will occupy a favorable position in the future technological competition.

(2)China has an absolute advantage in the number of patents, ranking first, the United States ranked second, and Japan ranked third; in terms of level of influence, the United States ranks first, Germany ranks second, China ranks third, and Japan ranks fourth; From the perspective of patent quality, the

United States is far ahead, China ranks second, and has a large gap with the United States. Therefore, while pursuing quantity, China also needs to pay attention to the quality of patents in order to increase its own influence, so that it can become a technology leader in the field of speech synthesis.

(3) There are many patentee organizations in the field of speech synthesis in China and the number of patents is not large. There is no single company, but the situation is the opposite in Japan. Nine of the top fifteen patentees in international speech synthesis technology are from Japan. And the total number of patents accounts for 62% of Japan's speech synthesis field; therefore, China can take advantage of its own research and development institutions to strengthen cooperation among various patentees in order to increase the influence of the domestic speech synthesis field.

(4) Both Germany and the United States attach great importance to the development of overseas markets and value the European market, so their international level is high; in contrast, China does not attach importance to the development of overseas markets, only the domestic market, so it is at the international level in a bad situation. In the future, Chinese companies can open up more foreign markets, improve their competitiveness, and increase China's influence in the field of speech synthesis.

References

- [1] Zhang Hongmian, Zhao Jinming. Research on the development trend of China's intelligent voice technology from patent perspective[J]. Chinese High Technology Letters, 2017,27(04):371-380.
- [2] He Juan, Du Mengting. Analysis of Key Technologies of Intelligent Finance Based on Global Patent Information and Its Enlightenment[J]. Science and Technology Management Research 2019, 39(19):190-199.
- [3] Ge Huilei, Zhan Ailan, Kou Dongxue. Research on Technology Innovation Trend and Development Countermeasures of Satellite Navigation Industry: Multi-dimensional Measurement Based on Patent Intelligence[J]. Information Studies: Theory & Application, 2020, 43(03):65-70.
- [4] Shao Peizhang. The Impact of the Third Amendment of Patent Law on Patent Acceptance and Authorization Based on the Empirical Analysis[J]. Electronics Intellectual Property, 2018(12):77-87.
- [5] MAO Hao, CHEN Da-peng, YIN Zhi-feng. A Theoretical Inquiry and Empirical Investigation on the Way towards Perfection of the "Dual Track" Patent Protection System in China[J]. China Soft Science, 2019(09): 1-17.
- [6] HANAT Riza, Nurbol. Bibliometric analysis of research status and development trend of speech synthesis technology[J]. Modern Electronics Technique, 2019,42(21):116-119+124.
- [7] Cui Xintong. Patent analysis of speech synthesis technology [J]. Electronic Technology & Software Engineering, 2018(04):142.
- [8] Huang Nanchuang, Deng Zhenjie, Wang Weiwei, Zhang Haojian. Research and Development in Synthetic Technology of the Pronunciation [J]. Journal of North China Institute of Aerospace Engineering, 2002(03): 37-39.
- [9] Liu Haoran, Du Limin. Development and Prospect for Speech Synthesis [J]. Journal of Network New Media, 2007(07):726-730.
- [10] ZHANG Bin, QUAN Chang-qin, REN Fu-ji. Overview of Speech Synthesis in Development and Methods [J]. Journal of Chinese Computer Systems, 2016, 37(01):186-192.
- [11] Chen Pan, Sha Yongzhong. The Patent H-index Analysis about Chinese "985" Universities [J]. Library & Information, 2014(05):53-60.
- [12] Lou Yan, Yang Peipei, Huang Lucheng, Miao Hong. Comparative Research on Chinese and Foreign Nuclear Power Technology Based on Patents [J]. Journal of Intelligence, 2016, 35(06):102-108.
- [13] Cao Lei. Patent information analysis for patent strategy [J]. Science and Technology Management Research, 2005(03): 97-100.
- [14] Chen Yue, Tan Jianguo, Wang Zhiqi, Liu Dong, Liu Zeyuan. Technological opportunity analysis of industrial robots from the perspective of patents [J]. Science Research Management, 2018,39(04):144-156.