Cardiovascular disease management using non-invasive biometric information
Level 4 self-driving vehicles
LXP-based personalized curation technology
Autonomous last-mile delivery service
The intelligent edge
Real-time collaboration platform using VR and hologram technology
Beyond-screen technology
Artificial Intelligence (AI) for cybersecurity
Hyper-realistic media production and broadcasting technology
Green packaging
Cardiovascular disease management using non-invasive biometric information

Level 4 self-driving vehicles

LXP-based personalized curation technology

Autonomous last-mile delivery service

The intelligent edge

Real-time collaboration platform using VR and hologram technology

Beyond-screen technology

Artificial Intelligence (AI) for cybersecurity

Hyper-realistic media production and broadcasting technology

Green packaging
Abstract

Research Background

● It is important to select emerging technologies to prepare for a transition into the ‘new normal era’ triggered by COVID-19 pandemic.

● KISTEP has identified 10 emerging technologies each year to be prepared for the leading trends (or issues) in Korea.

Research Process

● The research was carried out in four main steps including identification of future issues, nomination of technology candidates, selection of 10 emerging technologies, and in-depth analysis of the selected technologies.

Results

● In 2021, ‘untact era’ is designated as the leading trend for ‘KISTEP’ s 10 emerging technologies based on the public survey performed last year.

  ※ ‘Untact’ is a combination of prefix ‘un’ and the word ‘contact’ and has been a buzzword since the COVID-19 pandemic in Korea. It is a way of doing things without direct contact with others.

● ‘Future issues and technologies’ in the ‘untact era’ were selected based on experts opinions and literature review.

● ‘10 emerging technologies’ were selected based on the results from survey including experts from industry and academia, and research on patent trends. They are as follows:

  ① Non-invasive biometric information-based cardiovascular disease management, ② Level 4 self-driving cars for the transportation vulnerable, ③ LXP-based personalized curation technology for education, ④ Autonomous last-mile delivery service, ⑤ Intelligent edge computing, ⑥ Real-time collaboration platform using VR and Hologram technology, ⑦ Beyond-screen interface, ⑧ Artificial Intelligence (AI) security, ⑨ Hyper-realistic media production and broadcasting technology, ⑩ Green packaging

Conclusion and Implications

● ‘KISTEP 10 emerging technologies’ are expected to be a countermeasure to meet the future needs, such as the change in population structure (due to low birth and aging), personalized services and social safety net.

● Currently, the level of ‘untact’ services and technology in Korea is evaluated as ‘average’ and ‘follower’, respectively.

● To promote the commercialization of emerging technologies, further research on analyzing factors and regulations hampering technical commercialization is required.
I. Research Background

Since the COVID-19 coronavirus pandemic (hereinafter referred to as COVID-19) has led a rapid transition to the new normal, the importance of strategic foresight has become greater.

- Identifying various issues that could arise in the future and developing promising technologies will be directly related to the success and failure of the nation and businesses.
- The scientific and technological advances are taking place at a breathtaking pace. It is expected that we will soon meet the era when a technology leads the development of other technologies based on the convergence with innovations in the 4th industrial revolution such as AI and big data.

※ It took 8,000 years for humans to witness the transition from the agricultural revolution into industrial revolution. However, it took only 10 to 100 years to explore the moon or understand the human genome.

A number of research institutes have provided information on emerging technologies in order to explore new industries and prepare for changes in the future

- Massachusetts Institute of Technology released 10 breakthrough technologies that are expected to have widespread consequences for human life in the coming year based on the opinions of best experts in each field
- World Economic Forum presented top 10 emerging technologies that may have a major impact within the next 5 years based on opinions and evaluation of expert groups
- Gartner identified the top 10 strategic technology trends for the year that are likely to exert a great influence on IT and business or garner interest from large investment management companies worldwide

- IBM explored emerging technologies that may change the world for the next 5 years among the ones that are developed by IBM’s research
- Korea Institute of Science and Technology Information, KISTI released emerging technologies to create new market and industries using big data analysis and deep learning techniques
- Korea Research Institute of Bioscience and Biotechnology, KRIBB presented promising technologies that will contribute to innovating the bio industry and increasing added value through the literature review and in-depth discussion with experts

Since 2009, KISTEP has selected 10 emerging technologies that may have a major impact on the society, economy, and environment each year

- Since 2013, KISTEP has identified key issues* of the future Korean society and selected emerging technologies as countermeasures to these issues

- KISTEP selected 10 emerging technologies for the next 10 years based on the literature review, survey, patent analysis, professional meetings, and expert opinions
### Table 1: Emerging technologies selected by research institutes

<table>
<thead>
<tr>
<th>Research institutes</th>
<th>Topics and methods</th>
</tr>
</thead>
</table>
| **KISTEPT**<sup>10</sup> Emerging technologies**<sup>“</sup> | ▶ Topics: Emerging technologies as countermeasures for key future trends  
▶ Methods: Literature review and expert opinions, etc.  
① Select major trends based on the literature review and expert opinions, etc.  
② Explore key future issues related to major trends  
③ Select promising technologies within 10 years from the survey and expert opinions  
④ In-depth analysis on each emerging technology |
| **KISTI**<sup>10</sup> Emerging technologies**<sup>“</sup> | ▶ Topics: Emerging technologies to create new market and industries in the future  
▶ Methods: Big data analysis and deep learning techniques based on the data from literature review  
① Create a map of science and technology from the research data  
② Observation and monitoring of technology clusters  
③ Apply the predictive model on potential growth of technology clusters based on machine learning  
④ Apply the quantitative/qualitative assessment criteria to candidate technologies that are highly likely to advance in 7 years to select emerging technologies in final |
| **KRIBB**<sup>10</sup> 10 emerging biotechnologies<sup>“</sup> | ▶ Topics: Emerging technologies that can innovate the bio industry and increase added value  
▶ Methods: Literature review, in-depth discussions with experts, etc.  
① Identify candidate technologies from in-depth discussions with experts based on reference comparison of the recent research on biotechnologies and analysis on the network of keywords  
② Prepare a survey to assess the implications of candidate technologies |

**Research institutes**
- KISTEPT
- KISTI
- KRIBB
- MIT
- WEF
- Gartner
- IBM

**Topics and methods**
- MIT Technology Review
  - "10 Breakthrough Technologies"
  ▶ Topics: Emerging technologies that are expected to have widespread consequences for human life in terms of the society and economy  
▶ Methods: Select the promising technologies based on the advice of best experts in each field

- WEF "Top 10 Emerging Technologies"
  ▶ Topics: Emerging technologies that will bring a positive impact to the humanity in 5 years  
▶ Methods: Candidate technologies are evaluated by the International Steering Committee consists of 11 experts for the selection

- Gartner "Top 10 Strategic Technology Trends"
  ▶ Topics: Promising IT technologies that are expected to be in the spotlight within 3 to 5 years  
▶ Methods: Technologies that may disrupt the IT industry and business or garner the interest of large investment management companies are evaluated for the selection

- IBM "5 in 5"
  ▶ Topics: Promising technologies that may change the world in 5 years among the ones developed by IBM Research  
▶ Methods: Selected among the ones that IBM Research is working on to respond to certain future issues
II. Research Process

The research was carried out in four main steps including identification of future issues, nomination of technology candidates, selection of 10 emerging technologies, and in-depth analysis of the selected technologies.

Identification of future issues: A series of issues to be considered as important in the future of Korea were explored by reviewing published literatures and gathering opinions from experts.
- Opinions from technology foresight experts, advisory members of the Presidential Advisory Council on Science & Technology (PACST), etc. were gathered through a survey.

Selection of technology candidates: Technology candidates to respond to future issues were identified through Committee on emerging technologies and literature review.

Selection of 10 emerging technologies: Surveyed general public and experts to assess the priorities and held meetings with experts engaging in the sector of candidate technologies to evaluate their feasibility and current status.
- Based on the patent analysis of each technology candidate, its technology growth stage, number of patent applications, Herfindhal-Hirschman Index (HHI) were calculated.
* It is defined as the sum of the squares of the market shares of the firms within the industry, where the market shares are expressed as fractions. The result is proportional to the average market share, weighted by market share.

Comprehensive analysis of the selected technologies: A comprehensive analysis of the selected technologies, including the definition and scope of technologies, global trends in policy, industry, and technology, future outlook in 2030, and advices for policy makers.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Research process</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>(1) Identification of future issues</td>
<td>Build a DB on future issues based on published materials of technology foresight</td>
</tr>
<tr>
<td>Evaluation of priorities</td>
<td>Assess priorities based on opinions of PACST advisory members and technology foresight experts</td>
</tr>
<tr>
<td>Selection of the candidates for emerging technologies</td>
<td>Gather opinions from experts and KISTEP researchers to assess the priorities</td>
</tr>
<tr>
<td>Selection of emerging technologies</td>
<td>Conduct a public survey to assess the priority of candidate technologies selected in the first round</td>
</tr>
<tr>
<td>Evaluation of technology candidates</td>
<td>Hold professional meetings to evaluate the feasibility and current status of each candidate</td>
</tr>
<tr>
<td>Selection of emerging technologies</td>
<td>Select technology candidates for the 2nd round based on the result of survey and meeting</td>
</tr>
<tr>
<td>Comprehensive analysis of the selected technologies</td>
<td>Select 10 emerging technologies in final through the patent analysis and discussions with KISTEP researchers</td>
</tr>
</tbody>
</table>

---

[Table 2] Survey evaluation indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts</td>
<td>Impacts of the issue on Korean economy, society, and environment for the next 10 years</td>
</tr>
<tr>
<td>The role of Science and Technology</td>
<td>The role of the science and technology to meet the demands that may occur with regard to the issue for the next 10 years</td>
</tr>
</tbody>
</table>

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Evaluation of priorities:
- Assess priorities based on opinions of PACST advisory members and technology foresight experts.
- Gather opinions from experts and KISTEP researchers to assess the priorities.

Selection of the candidates for emerging technologies:
- Build a DB on emerging technologies through keyword search on media reports.
- Update the DB through literature review on technology foresight and publications from other research institutes.
- Hold meetings with the Committee on emerging technologies to review candidate technologies and assess the consistency with future issues.

Selection of emerging technologies:
- Conduct a public survey to assess the priority of candidate technologies selected in the first round.
- Hold professional meetings to evaluate the feasibility and current status of each candidate.
- Select technology candidates for the 2nd round based on the result of survey and meeting.
- Select 10 emerging technologies in final through the patent analysis and discussions with KISTEP researchers.
Major trends in the future Korean society identified by literature review are as follows:

- **Politics**
  Emergence of rising nations and developing countries, rise in protectionism, conflicts between ethnic groups, religions, and nations, hyper-globalization, improving relations with North Korea, etc.

- **Economy**
  Economic disparity, emergence of Asia in global economy, growth of untact industry, sluggish growth of the world economy, increase in global trade, etc.

- **Society**
  Increasing threats to safety, urbanization, low birth rate and population aging, individualism, contactless society, intensified inequality and polarization, multicultural society, etc.

- **Environment**
  Lack of food and water resources, climate change, ecosystem destruction, decarbonization, decentralized electrification, circular economy, and development of renewable energy, etc.

- **Technology**
  Hyper-connectivity and super-intelligence, spread of infectious disease and healthcare innovation, hyper-speed transport, development of nanotechnology, AI and automation, etc.

### Table 4: Future societal trends

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Politics</strong></td>
<td>Multipolarization of global order, emergence of rising nations and developing countries, multi-level governance structure, return of big government and decline of hyper-globalization after COVID-19, emergence of surveillance society, increasing scope of governance from globalization, rise in protectionism, rising conflicts in ethnicity and nation, improved relations with North Korea, etc.</td>
</tr>
<tr>
<td><strong>Economy</strong></td>
<td>Integration of the world market, global trade increase, economic disparity, full-fledged discussions on universal basic income, growing influence of China, emergence of Asia in global economy, transformation of GVC after COVID-19, digital economy, paradigm shift in the manufacturing industry, growth of contactless industry, sluggish growth of the world economy, etc.</td>
</tr>
<tr>
<td><strong>Society</strong></td>
<td>Rising threat to safety, intensified inequality and polarization, low birth rate and population ageing, decreasing population, urbanization, hollowization in regions, growth of smart small/medium-sized cities, me-centered society, changes in the concept of family, structural change in employment, emergence of new employment relationship, demise of lifetime workplace and employment, spread of contactless platform, increasing civic engagement, multicultural society, inclusive growth, globalization fueling populism, improving status of women, spread of on-demand learning, etc.</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>Energy consumption increase and weaponization, low carbonization and decentralized electrification, worsening lack of food and water, severe global warming and increase of natural disasters, promotion of greenomics, strengthening circular economy, post carbon life, ecosystem destruction intensified, etc.</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Hyper-connectivity and super-intelligence, AI and automation, prevention of personal data breach, increasing life expectancy, acceleration in adopting telemedicine system, development of new materials, development of nanotechnology, age of aerospace, hyper-speed transport, etc.</td>
</tr>
</tbody>
</table>

※ Source: Science & technology foresight, Inclusive Korea, Science and technology future vision, Challenges & Choices for Europe, Paradox of Progress, Foresight 2019, Global issue, State of the future
Issues that are considered to have a great impact to Korean society and economy in the next 10 years were selected

- Future issues that were previously selected as KISTEP 10 emerging technologies were excluded, and they were narrowed down to the final 7 candidates* based on review by experts and KISTEP researchers

  * Smart green society, urban concentration, era of Millennials, untact society, rise in protectionism, growth of Asia in the global economy, X-event

- Impacts and the role of science and technology related to each issue was reviewed by experts

As a result, the ‘untact society’ was selected as the topic of 2021 KISTEP emerging technologies

- ‘Untact technologies’ are defined as direct or indirect technologies* that can be supported by the same or similar products and services even though people do not face each other directly

  * Types of untact technologies include alternative technologies (that change face-to-face services into contactless ones), response technologies (that contribute to advancing contact-free services derived from the untact society and solving problems), and base technologies (that improve customer satisfaction in terms of speed, accuracy, etc. of online and remote services)

### Table 5: Impacts and the role of science and technology of future issues

<table>
<thead>
<tr>
<th>Issues (%)</th>
<th>Impacts (%)</th>
<th>The role of science and technology (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerging technology accelerating transition to smart green society</td>
<td>15.3</td>
<td>16.1</td>
<td>15.7</td>
</tr>
<tr>
<td>Emerging technology to prepare for urban concentration</td>
<td>13.5</td>
<td>13.5</td>
<td>13.5</td>
</tr>
<tr>
<td>Emerging technology to prepare for the generational shift to Millennials</td>
<td>13.8</td>
<td>13.3</td>
<td>13.6</td>
</tr>
<tr>
<td>Emerging technology to prepare for the untact society</td>
<td>16.4</td>
<td>16.4</td>
<td>16.4</td>
</tr>
<tr>
<td>Emerging technology to prepare for rise in protectionism</td>
<td>14.9</td>
<td>13.8</td>
<td>14.4</td>
</tr>
<tr>
<td>Emerging technology to prepare for the rise of Asia in the global economy</td>
<td>13.1</td>
<td>12.7</td>
<td>12.9</td>
</tr>
<tr>
<td>Emerging technology to prepare for X event</td>
<td>13.0</td>
<td>14.0</td>
<td>13.5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Views on the Future of Untact Society

Korea will shift to the untact society rapidly within the next 10 years, especially in the field of ICT.

The satisfaction level on untact services in Korean society triggered by COVID-19 is ‘average’ or ‘satisfied’ level, and it is recognized that the role of science and technology is very important.

(a) Speed of transition to untact society
(b) Sectors to adopt untact product/service
(c) Level of satisfaction on untact services
(d) The role of S&T
Respondents answered that the reduction of social cost and acceleration of digital transformation were the most positive impacts of the untact society.

<table>
<thead>
<tr>
<th>Positive Impact</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of social costs by work from home and less traffic congestion, etc.</td>
<td>23.5</td>
</tr>
<tr>
<td>Acceleration of the development of digital technologies (AI, blockchain, etc.)</td>
<td>17.1</td>
</tr>
<tr>
<td>Creation of new business models or industries (ex. big data industry, etc.)</td>
<td>16.8</td>
</tr>
<tr>
<td>Increase in customer satisfaction with tailored/personalized service</td>
<td>11.1</td>
</tr>
<tr>
<td>Improving work/life balance by more leisure activities</td>
<td>10.3</td>
</tr>
<tr>
<td>More information/data sharing and pop culture</td>
<td>8.4</td>
</tr>
<tr>
<td>Increased global recognition of Korea with the spread of K-quarantine, K-pop, K-wave</td>
<td>6.7</td>
</tr>
<tr>
<td>Establishing the concept of digital assets</td>
<td>6.1</td>
</tr>
<tr>
<td>Others</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Respondents considered that the reduction of jobs and the spread of individualism as negative impacts of the untact society.

<table>
<thead>
<tr>
<th>Negative Impact</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of jobs and replacement of labor</td>
<td>18.1</td>
</tr>
<tr>
<td>Lack of social communication and spread of individualism</td>
<td>17.9</td>
</tr>
<tr>
<td>Decrease of real economy and consumption</td>
<td>11.5</td>
</tr>
<tr>
<td>Privacy and cyber security issues</td>
<td>10.7</td>
</tr>
<tr>
<td>Spread of fake news and information</td>
<td>10.2</td>
</tr>
<tr>
<td>Widening gap depending on the presence/absence of benefits (increase of the underprivileged) and intensifying conflicts</td>
<td>9.6</td>
</tr>
<tr>
<td>Increasing environmental pollutions (waste, etc.) due to the rise of online shopping</td>
<td>9.4</td>
</tr>
<tr>
<td>More delinquent behaviors among the youth</td>
<td>5.2</td>
</tr>
<tr>
<td>Emergence of large local providers as large platforms and their dominant status (in Korea)</td>
<td>5.2</td>
</tr>
<tr>
<td>Dominance of global companies and products in local market (overseas→Korea)</td>
<td>1.7</td>
</tr>
<tr>
<td>Others</td>
<td>0.4</td>
</tr>
</tbody>
</table>

※ The survey was conducted (October 2020) among 500 respondents.
The needs of untact society in Korea regarding 10 sectors were identified as follows:

**Construction**
Increasing demand on smart housing tailored to changing demographic structure (single person household, populating aging, etc.), living environment safe from infectious disease, advanced facility management, etc.

**Transportation**
Safe smart mobility, providing information on travel routes of persons confirmed with infectious disease, more services for pedestrians, the elderly and individuals with disabilities.

**Education**
Personalized learning services, diversification of learning methods, improving online communications, counseling on the youth, etc.

**ICT**
Demand on hyper-speed, ultra-low latency, hyper-connectivity, hyper-intelligence, high reliability, unmanned ICT network.

**Finance**
Bridging the digital divide, increasing demand on online payment/settlement systems, increased P2P financial transactions, hyper-personalization of asset management, etc.

**Data security**
Transparent data and removal of fake information, diversification of security methods (contact-free, biometrics, etc.), safe management of personal information, etc.

**Healthcare**
Spread of individual health services and contact-free services (diagnosis, medical counseling, treatment, etc.), prompt diagnosis and treatment of zoonosis, supply of safe food, etc.

**Energy/environment**
Enhancing the convenience of energy consumers, remote metering solutions, easy recycling and garbage collection, etc.

**Manufacturing**
Automation and increasing use of robots, flexibility on production output, remote maintenance management for entire factory simulation and decision making, etc.

**Consumption**
Facilitation of subscription economy and advanced logistics system using autonomous driving, etc.

The candidates for technologies to meet the needs in the future society were reviewed, and a total of 14 technologies were selected by experts.

- The technology candidates were identified among the ones that could meet the needs of future society by literature review, media reports, and gathering the opinions of experts.
- 14 candidate technologies were selected based on the coherence with the topic (untact society), impacts, etc.
### III. Results

**[Table 6] The candidates for emerging technologies**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Coherence with the topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-invasive biometric information processing</td>
<td>A non-invasive technology for self-health management by using optical/electrochemical properties instead of obtaining medical and biological information by blood or skin invasive method</td>
<td>non-invasive technique allowing the self-health management instead of going to the hospital</td>
</tr>
<tr>
<td>Level 4 self-driving cars for the elderly and people with disabilities</td>
<td>Level 4 autonomous driving technology for the disabled, elderly, and those living in remote areas excluded from the benefits of public transportation</td>
<td>Self-driving cars for the disabled and elderly to the destination without an accompanying person</td>
</tr>
<tr>
<td>Control and monitoring of public transport regarding health related issues</td>
<td>A monitoring technology used to track the use of public transport by people confirmed with an infectious disease</td>
<td>Minimizing contacts with those confirmed with the infectious diseases</td>
</tr>
<tr>
<td>AI-based adaptive learning technologies for individual learning</td>
<td>Providing information and methods of learning based on the level and study style of learners</td>
<td>Enhancing the user satisfaction of online learning by providing contact-free features</td>
</tr>
<tr>
<td>Learning eXperience Platform (LXP)-based personalized curation technology</td>
<td>Providing personalized contents based on the user data</td>
<td>Enhancing the user satisfaction of online learning by providing contact-free feature</td>
</tr>
<tr>
<td>AI/robot-based warehouse/logistics system</td>
<td>Intelligence and automation of process including frequent loading/unloading of multi-items in small-volume and delivery from the logistics (fulfillment) center to the customer</td>
<td>Enhancing the efficiency of online shopping</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Coherence with the topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot/vehicle/drone-based last mile delivery service</td>
<td>Unmanned last mile delivery using robots, vehicles, drones, etc.</td>
<td>Replacing face-to-face delivery services</td>
</tr>
<tr>
<td>The intelligent edge</td>
<td>An intelligent data processing near the network edge where data is generated, instead of centralized cloud computing</td>
<td>Improving the user satisfaction with low latency online service</td>
</tr>
<tr>
<td>Beyond-screen multi-platform</td>
<td>A UI/UX technology that maximizes interactions between humans and computer systems</td>
<td>Minimizing face-to-face contacts and enhancing the user satisfaction</td>
</tr>
<tr>
<td>Real-time collaboration platform using VR and Hologram technology</td>
<td>A technology used to generate and share the information anywhere with data encryption, network drive, etc.</td>
<td>Minimizing face-to-face services</td>
</tr>
<tr>
<td>Real-time monitoring technology against cyber threats</td>
<td>A technology used to monitor hacking activities, personal data breach, and other cyber threats in real time to protect against cybercrime</td>
<td>Resolving security-related problems of digital technologies</td>
</tr>
<tr>
<td>Hyper-realistic sports broadcasting technology</td>
<td>Providing immersive experience of sports broadcasting by using the latest technological advances such as AR, VR</td>
<td>Mimicking the experience of actual visits to sports, culture &amp; arts arenas</td>
</tr>
<tr>
<td>Ultra-compact freeform cell for smart devices</td>
<td>Power supply with ultra-compact freeform cells to improve hyper-connected usability, portability, and aesthetic values of smart sensors, wireless medical devices, logistics system, etc.</td>
<td>Support for services including telemedicine, smart healthcare, etc.</td>
</tr>
<tr>
<td>Green packaging for green shopping</td>
<td>Reduction of the volume of packaging materials and waste in everyday lives along with increased online shopping</td>
<td>Resolving environmental issues in line with the rise of online shopping</td>
</tr>
</tbody>
</table>
III. Results

Selection of 10 Emerging Technologies

10 emerging technologies were selected through the survey results, professional meetings, patent analysis of each candidate.

Survey
The implication of each candidate was measured by using a 5-point scale and most of them scored ‘high’.
- Among technology candidates, ‘real-time monitoring technology against cyber threats’ seems to have the most impact.
- On the contrary, ‘beyond-screen interface’ and ‘hyper-realistic sports broadcasting technology’ seem to have limited applications and low impact.

[Table 7] Impact of candidate technologies

<table>
<thead>
<tr>
<th>Sector</th>
<th>Technology</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT</td>
<td>Real-time monitoring technology against cyber threats</td>
<td>4.14</td>
</tr>
<tr>
<td>Consumption</td>
<td>AI/robot-based warehouse/logistics system</td>
<td>4.05</td>
</tr>
<tr>
<td>Education</td>
<td>AI-based adaptive learning technologies for individuals</td>
<td>4.02</td>
</tr>
<tr>
<td>Energy/environment</td>
<td>Shape-shifting microbatteries for smart devices</td>
<td>3.95</td>
</tr>
<tr>
<td>ICT</td>
<td>Real-time collaboration platform using VR and Hologram technology</td>
<td>3.92</td>
</tr>
<tr>
<td>Consumption</td>
<td>Robot/vehicle/drone-based last mile delivery service</td>
<td>3.9</td>
</tr>
<tr>
<td>Education</td>
<td>LXP-based personalized curation technology</td>
<td>3.88</td>
</tr>
<tr>
<td>Transportation</td>
<td>Level 4 self-driving vehicles</td>
<td>3.85</td>
</tr>
<tr>
<td>ICT</td>
<td>The intelligent edge</td>
<td>3.85</td>
</tr>
<tr>
<td>Energy/environment</td>
<td>Green packaging</td>
<td>3.85</td>
</tr>
<tr>
<td>Medicine</td>
<td>Non-invasive biometric information processing</td>
<td>3.84</td>
</tr>
<tr>
<td>Medicine</td>
<td>Control and monitoring of public transport regarding health-related issues</td>
<td>3.83</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Beyond-screen technology</td>
<td>3.82</td>
</tr>
<tr>
<td>Culture</td>
<td>Hyper-realistic sports broadcasting technology</td>
<td>3.66</td>
</tr>
</tbody>
</table>

※ Survey respondents: 478 KISTEP policy customers (Oct, ’20), impact: 1 (very low)–3 (moderate)–5 (very high)

Patent analysis
Most of the technology candidates are in the ‘growth’ stage, and they will be in a high level of market readiness with the support of active R&D.
- A patent analysis was conducted after adjusting the scope of 14 candidate technologies through professional meetings.
- The number of patent applications is gradually increasing, which indicates the R&D of relevant technologies is in the ‘growth’ stage.

[Table 8] Growth trends of candidate technologies

(a) Cardiovascular disease management using non-invasive biometric information
(b) Health monitor system in public transportation
(c) Level 4 self-driving vehicles
(d) AI-based adaptive learning technologies for individuals
(e) LXP-based personalized curation technology
(f) AI/robot-based warehouse/logistics system
III. Results

<table>
<thead>
<tr>
<th>Technology candidates</th>
<th>No. of patents (’09~’18)</th>
<th>Concentration ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-invasive biometric information-based cardiovascular disease management</td>
<td>1,240</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Health monitor system in public transportation</td>
<td>309</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Level 4 self-driving vehicles</td>
<td>694</td>
<td>Korea 2</td>
</tr>
<tr>
<td>AI-based adaptive learning technologies for individuals</td>
<td>166</td>
<td>Korea 2</td>
</tr>
<tr>
<td>LXP-based personalized curation technology</td>
<td>55</td>
<td>Korea 3</td>
</tr>
<tr>
<td>AI/robot-based warehouse/logistics system</td>
<td>323</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Autonomous last-mile delivery service</td>
<td>508</td>
<td>Korea 2</td>
</tr>
<tr>
<td>The intelligent edge</td>
<td>795</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Beyond screen technology</td>
<td>4,031</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Real-time collaboration platform using VR and Hologram technology</td>
<td>344</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Real-time monitoring technology against cyber threats</td>
<td>1,017</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Hyper-realistic media production and broadcasting technology</td>
<td>372</td>
<td>Korea 2</td>
</tr>
<tr>
<td>Shape-shifting microbatteries for smart devices</td>
<td>255</td>
<td>Korea 3</td>
</tr>
<tr>
<td>Green packaging</td>
<td>463</td>
<td>Korea 2</td>
</tr>
</tbody>
</table>

※ Concentration ratio: 1 (very high level of the ease of market entry), 2 (high), 3 (medium), 4 (low), and 5 (very low)
※ Note: There are some limitations to interpret the result to calculate Herfindahl–Hirschman Index (HHI) in case where there is a small number of patent applications

Also, it appears that there is little degree of application of the candidate technologies in the Korean and Chinese markets. Meanwhile, AI-based security technologies in Japan forms a competitive market.
### 2021 KISTEP 10 Emerging Technologies

Based on thorough analysis, 1 to 2 technologies with high profile are selected per sectors, and KISTEP 10 emerging technologies in the untact era for 2021 are as follows:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Emerging technologies</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine</td>
<td>Cardiovascular disease management using non-invasive biometric information</td>
<td>A technology to obtain biometric information through optics, ultrasound, and other non-invasive methods to monitor cardiovascular disease</td>
</tr>
<tr>
<td>Transportation</td>
<td>Level 4 self-driving vehicles</td>
<td>Level 4 autonomous driving technology to provide the benefits of mobility, safety, convenience by using various modes of transportation including public transport, ridesharing for the elderly and individuals with disabilities</td>
</tr>
<tr>
<td>Education</td>
<td>LXP-based personalized curation technology</td>
<td>A platform where personalized curriculum and methods of learning are provided to users while providers can offer various methods, levels, and types of learning to users</td>
</tr>
<tr>
<td>Consumption</td>
<td>Autonomous last-mile delivery service by using unmanned devices (robots, drones, etc.)</td>
<td>A technology enabling the last-mile delivery service by using unmanned devices (robots, drones, etc.)</td>
</tr>
<tr>
<td>ICT</td>
<td>The intelligent edge</td>
<td>A technology that utilizes the resources of edge computing nodes efficiently and provides functions to connect, compute, and control</td>
</tr>
<tr>
<td>ICT</td>
<td>Real-time collaboration platform using VR and Hologram technology</td>
<td>A platform that supports companies or individuals to help their consumers utilize AR/hologram services conveniently</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Beyond screen technology</td>
<td>A series of technologies that provide analysis of Natural User Interface (NUI) and various user environment data in the hyper-connected era, so that they can be properly processed or output to the optimal UI for the user environment</td>
</tr>
<tr>
<td>Security</td>
<td>Artificial Intelligence (AI) security</td>
<td>An AI-based technology that automatically analyzes and classifies threats using AI technology or to secure the stability of AI models and defend against attacks using AI</td>
</tr>
<tr>
<td>Culture</td>
<td>Hyper-realistic media production and broadcasting technology</td>
<td>A technology that uses immersive media such as AR, VR, etc. to produce and broadcast contents including sports, entertainment, movies, etc.</td>
</tr>
<tr>
<td>Environment</td>
<td>Green packaging</td>
<td>A technology that uses packaging materials made of eco-friendly biodegradable plastics</td>
</tr>
</tbody>
</table>
III. Results | Present and future of 10 emerging technologies in the untact era

01 Sector Medicine Technology

Cardiovascular Disease Management Using Non-invasive Biometric Information

**Background**
A growing need to develop smart monitoring and diagnostic technologies due to the aging population and increasing cases of chronic cardiovascular diseases

- Earlier invasive approaches (e.g. withdrawal or injection) require a surgical procedure or frequent replacement, which causes anxiety issues of patients
- Compared to previous methods, the non-invasive methods enables constant and convenient monitoring

**R&D trends**
Korea and China are in the stage of developing core technologies, but the US and other leading countries have already expanded such technologies into non-invasive medical services

**Korea**
Korea is advanced in miniaturization and algorithm-based signal processing techniques while high-performance core technologies are still in the development phase

※ Samsung Advanced Institute of Technology (non-invasive measuring of blood sugar level using Raman spectroscopy), Jeonbuk National University (blood sugar monitoring using zinc oxide)

**USA**
Technologies that can serve patients directly are more advanced than technologies related to devices

※ Apple (wearable blood sugar solution), Bigfoot Biomedical (blood sugar level monitoring system) etc.

**China**
Solutions such as optical methods to determine heart function and oxygen saturation level are included in the product. However, technologies to monitor blood sugar level and blood pressure are in the development stage

※ Nanjing University (diabetes detection using respiration), Tianjin University (diabetes detection using intravascular near-infrared spectroscopy), etc.

**Future Outlook in 2030**
The global biometric information market for monitoring sensor is growing rapidly as non-invasive medical services have expanded in most countries

- Due to the rapid increase of the patients with chronic conditions and the expansion of smart devices, disease monitoring will be possible without temporal and spatial constraints
- Medical data acquisition and the application of AI technologies will affect the degree of real-time cardiovascular disease management
III. Results

Japan Level 4 autonomous driving service will be available by 2025~2028, and unmanned/self-driving cars are being tested as an option to resolve the aging population issue

- DeNa (demonstration of transportation services for the elderly to medical institutes), Toyota (service development in collaboration with Amazon and Uber)

EU Autonomous driving shuttle services are being tested, especially in the areas where public transportation is not available

- Germany (plans to commercialize self-driving cars by 2020), EasyMile, France (EZ10 sales and lease)

Future Outlook in 2030
Self-driving vehicles for the elderly and individuals with disabilities will be easily available in our daily life

- People with the hearing impairment will be able to drive a taxi with autonomous driving technology
- Rural and remote areas will utilize robotaxis* with autonomous ridesharing technologies

* It provides the unmanned ridesharing services with the autonomous driving feature

Background
To respond to low birth rate and aging population, self-driving vehicles are necessary for the safe and convenient life of the elderly and individuals with disabilities

- The current service for the elderly and individuals with disabilities is only available through reservations even in emergency
- Rural areas tend to have a high demand for self-driving cars due to high percentage of the elderly in the population, and it is easier to implement services than urban areas

R&D trends
Although many countries invest vigorously to develop level 4 self-driving cars, research on the service to support the elderly and individuals with disabilities in Korea is still in the early stage of development

Korea Government plans to commercialize level 4 self-driving cars by 2027 and plans to support for the disabled and elderly starting from 2021

- Autonomous driving technology development program includes the development of mobility support service for the elderly and individuals with disabilities (KRW 1.974 trillion for 2021~2027)
III. Results

LXP-Based Personalized Curation Technology

Background
A growing social demand to establish an integrated learning environment to foster future talents and provide personalized education

- Unlike traditional LMS, it is necessary to develop a platform that can provide various learning methods, levels, and types
- LXP system runs independently in a standardized environment where interfaces and data

R&D trends
The global EduTech market has shifted from the management-specialized LMS to LXP

USA
Technology standards in the private sector are applied to designing a framework for education and training programs
※ Department of Defense (Total Learning Architecture program), OpenEdx (Insight service)

UK
The Ministry of Education is developing EduTech-related policies including LendED*
※ LendED provides online rental services of about 150 EduTech products and services

Future Outlook in 2030
The age of “Universal Education Access” will be available without temporal and spatial limits

- With the rapid development of AI, big data, and cloud (ABC) technologies, the idea of “learning is happening everywhere” will be widely used
- Korea will commercialize learning analysis technologies that can meet the global standards and the major countries will develop a more advanced system using learning analysis

Korea
Public education system* plans to adopt EduTech to build a personalized learning environment and SMEs are key actors in e-learning industries

* Recommendations to promote the edutech for future learning (The Presidential Committee on the 4th Industrial Revolution, Nov., ‘20)
III. Results

Present and future of 10 emerging technologies in the untact era

**Autonomous Last-Mile Delivery Service**

**Background**
The rapid rise of logistics and food delivery service due to COVID-19 and changes in the demographic structure of Korea (aging population, increase of single-person household, etc.)

- It is necessary to increase the productivity of the labor-intensive logistics industry, and find a solution to decrease in labor force and productivity due to the aging population.
- Due to COVID-19, demand for daily necessities has increased as outside activities have been restricted.

**R&D trends**
Private companies are eager to dive in the autonomous delivery market along with the government’s efforts to reform regulations on the logistics industry.

**Korea**
Last-mile delivery robots and drones have recently entered into the pilot test stage.

- Robots (pilot food delivery service using robots), CJ logistics and Post Office (demonstration of drone services for emergency rescue and express mail delivery to remote or mountainous areas).

**USA**
Major companies are using delivery robots or drones to deliver small packages while startups test pilot food delivery services.

- Amazon (test service via Scout delivery robots and Prime Air), Marble (collaboration with food delivery service provider EAT24 to test run robots in San Francisco).

**EU**
EU is implementing a public-private partnership program (Sparc) and companies are driven to engage in last-mile pilot delivery services.

- DHL (the world’s first drone medical delivery), Starship Technologies (multiple test services with the goal of delivering parcels within 3km).

**Future Outlook in 2030**
The logistics industry will be replaced with autonomous delivery robots and drones, which will result in the rapid rise of online market.

- Since the hyper-connected technology on the roads and buildings has been standardized, establishment of floor-to-floor transportation and communication infrastructure for unmanned vehicles will be completed.
- A new types of delivery services will be emerged along with delivery robots and mobile CVS.
USA Active R&Ds in edge computing platforms and edge computing use cases, especially in the semiconductor, cloud, communication, automobile industries
※ Carnegie Mellon University/Huawei/Intel/NTT/Deutsche Telekom, etc. (launched the Open Edge Computing Initiative), Intel (xeon D-2100 processor), Nvidia (DGX-1 and DRIVEPX2)

China Currently developing V2X network, and MEC open-source platform
※ Huawei (5G V2X for intelligent connected vehicles), Baidu (BIE, China’s first intelligent edge)

Future Outlook in 2030
The intelligent edge with 5G network will be utilized in the fields where low latency data processing is required

- The intelligent edge will be used in diverse business sectors including smart factory, autonomous vehicles, remote monitoring and management (RMM), and smart healthcare
- An open, compact, and cost-effective ecosystem will be created through a communal intelligent edge, and the network infrastructure

Background
The explosive growth of the IoT and IoT devices promotes the development of new and faster data processing technology, which can replace current centralized cloud computing

- Along with the rapid development of AI technologies and related services, centralized cloud computing has already reached limitations in processing condensed data
- The massive amounts of data transfer between IoT devices and a cloud server often times cause latency issues or temporary network failures

R&D trends
Research institutes are collaborating with each other to provide more use cases, and to accelerate commercialization of the service

Korea R&Ds focus on the intelligent edge and home edge computing platforms; B2B edge services are launched by IT companies
※ ETRI (AI-based intelligent edge networking technology), Namutech (container-based multi cloud/hybrid cloud platform technology), KT (manages 5G mobile edge data centers in 8 major cities in Korea)
III. Results | Present and future of 10 emerging technologies in the untact era

US<br>NITRD* leads the national R&D on VR/AR technology; the IT companies provide diverse VR/AR products and services<br>※ a group of 24 U.S. federal agencies that support R&D activities in advanced information technologies<br>※ Facebook (Facebook Spaces), Looking Glass Factory (desktop holographic display)

EU<br>Developing a new personalized hologram coach platform for virtual coaching of older adults with balance disorders via Horizon 2020 HOLOBALANCE program; a new industrial ecosystem is being created by involving diverse stakeholders<br>※ The UK’s WaveOptics (product/device quality management using hologram technology), Germany’s Crytek (The Climb), etc.

Future Outlook in 2030<br>VR/Hologram technologies will enable people based in different location to participate in a project, in a 3D virtual space

Korea<br>Various types of core technologies for individuals or groups are being developed, and mobile carriers are developing services using their mobile networks<br>※ Samsung Advanced Institute of Technology (holographic display), KT (Pyeongchang 5G village), ETRI (prototype of tabletop digital holographic display), LG Uplus (VR video portal)

Background<br>A rapid growth of VR/AR service platforms for business and individuals

- With the advances in ICT and hardware capabilities, VR and AR can now provide virtual contents that are barely distinguishable from the reality
- Digital convergence accelerates the industrial convergence, and Korean customers tend to switch into large global platforms for more diverse contents

R&D trends<br>Current R&Ds focus on the development of integrated VR/AR platforms and technologies to enhance user experience
III. Results

Present and future of 10 emerging technologies in the untact era

**USA** The US has the most core technologies of gesture and/or voice recognition and UI/UX design, and the market using these technologies are being expanded

※ Invensense (MEMS motion tracking sensor), ReactJS (open source Javascript MVC for mobile app development)

**EU** Application of NUI technology is being developed mostly in the private sector; core technologies are being developed through various industry-academia projects

※ STMicroelectronics of Switzerland (ASM330LHH), Acapela Group SA of Belgium (speech synthesis B2B service), etc.

**Future Outlook in 2030** Interactive displays will replace interface devices

- UX design will be broadly used in the key application areas, such as autonomous driving, smart healthcare, and multimodal biometric system
- Voice/gesture recognition, eye tracking and brainwave will be a key part of the human-machine interface
- Collaboration between software and hardware companies will be expanded and the number of startups and SMEs will increase as well

**Background** Natural user interface, or NUI, has become easily accessible; user experience has become more diverse

- The development of digital technologies will lead to a hyper-connected society without temporal
- NUI uses human cognition instead of using traditional graphical user interface or directly typing commands

**R&D trends** Diverse NUI applications are being developed especially in the private sector, providing a more sophisticated interface to its customers

**Korea** IT companies are developing their own IoT platforms and advanced input/output technologies through standardization, AI, big data, and cloud computing

※ KIST (wearable 3D motion capturing sensor using optical fiber), tobesoft (Nexacro platform), TOMATO SYSTEM (eXBuilder6), TEGway (ThermoReal), etc.

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**Sector** Manufacturing Technology

**Beyond-Screen Technology**
III. Results

Present and future of 10 emerging technologies in the unta ct era

USA NITRD emphasized the importance of developing a safe AI security system, and the Department of Homeland Security has also stressed the significance of technology standardization.

CBInsight, a market research firm, recently presented a list of about 80 startups providing cyber security-related products and services; IT companies (e.g., Feedzai and Agari) invest more to R&Ds of AI-based security technologies.

EU EU increased investment in the AI ecosystem and cybersecurity R&D, and performed the pre-compliance tests for risk categorization of AI products and services.

Darktrace of the UK (AI-based IoT security and data breach solutions), Shift Technology of France (AI-based insurance fraud analysis solution), etc.

Future Outlook in 2030
Early detection of cyber threats and defense technologies will become critical in the future: advances in software and the communication network will enable personal cybersecurity monitoring.

AI-based cybersecurity systems will effectively detect and stop any massive cyber attacks.

Smart home security will be left out as a blind spot in the hyper-connected, hyper-intelligent era, but it could be monitored and controlled through personal devices.

Background
AI-based cybersecurity can be a solution to cyber attacks as AI technologies become easily accessible.

- AI creates innovation and builds social ecosystems including the areas of manufacturing, medicine, and transportation.
- A self-learning, AI-based cybersecurity can be a practical measure to the hyperconnected, hyperconverged, and hyperintelligent future.

R&D trends
Investment on AI security has been increasing; diverse security solutions are being developed especially in the private sector.

Korea The National Assembly of Korea passed the amendments to its three main data privacy laws in August 2020. Research is being carried out to improve cybersecurity using AI.

- Estsecurity (anti-malware solution), Igloo Security (AI-based integrated security systems), LG CNS (AI-based automatic detection of suspicious incoming network connections)
Hyper-Realistic Media Production and Broadcasting Technology

**Background**

The sports and entertainment industry has shown a rapid shift towards online after the COVID-19 pandemic.

- Decline in revenues in the sports and entertainment industry pushes stakeholders to seek alternative ways to make profits in the industry.
- 5G technologies have created a smart media environment where hyper-realistic media services can easily be accessed.

**R&D trends**

Hyper-realistic technology is widely used in diverse areas, such as in national defense, healthcare, and the media industry.

**Korea**

Interactive hyper-reality media production and broadcasting technologies are being developed and used in diverse areas.

- 4DREPLAY (immersive media production and broadcasting using multifocal displays and time slicing).
- ETRI (live broadcasting technology with 8K resolution 360 degree immersive video).

**USA**

Immersive media production and distribution platforms are being established to serve virtual contents in various sectors including national defense, culture, and sports.

- US Army (holographic map for military operation), Intel (True View and True VR provides immersive media experiences with rendering-based multi-perspective displays).

**Japan**

The Tokyo Olympic has prompted the development of diverse hyper-immersive media technologies.

- Softbank (broadcasts baseball games with 4DLIVE solution from 4DREPLAY), NHK (announced a plan to use holographic broadcasting technology for 2022 Worldcup), etc.

**Future Outlook in 2030**

A switch to interactive platform will improve customer satisfaction in various sectors.

- Hyper-realistic technologies will be utilized in various areas including healthcare, education and training, process improvement, logistics, and retails.
- Holographic technologies will be the base of broadcasting technology, and AI will deliver personalized experiences for customers.
III. Results

**Green Packaging**

**Background**
An innovative solution is needed to reduce and replace packaging materials, as online shopping is growing at a fast rate.

- There was a significant surge in single-use plastics as COVID-19 continues, creating a serious environmental concern.
- Reducing plastic waste and a circular economy have been a major environmental trend in the past few years: however, the plastic waste continues to increase as a contactless economy becomes a new normal with the pandemic.

**R&D trends**
The central and local governments have tightened environmental regulations to reduce wastes, and private companies invest more to develop eco-friendly products and green packaging materials to comply with the regulations.

**Korea**
Single-use plastic items will be banned starting from 2030, which leads the private sector to invest more on R&D associated with bioplastics.

- SR Technopack (GB-8), Amorepacific (uses metal-free pumps to their cosmetic packaging), Ourhome (uses biodegradable plastic bags in their shops)

**USA**
Manufacturers began to use green packaging materials as many local governments impose stricter restrictions on the use of single-use plastic items.

- California (banned plastic straws in all restaurants excluding fast food restaurants for the first time in the US since 2019), Seattle (banned plastic utensils since July, 2018)

**EU**
Adopted a new Circular Economy Action Plan: the action plan includes environmental regulations to achieve sustainable growth in the EU.

- EU (plans to achieve a 90% collection target for plastic bottles by 2025), France (plans to use minimum 60% of biobased, biodegradable materials in single-use plastics by 2025)

**Japan**
Recently presented a national plan to adopt sustainable bioplastics, and adopted legislation to regulate plastics by implementing plastic bag charges since July 2020.

**Future Outlook in 2030**
A higher priority will be given to green packaging for both consumers and manufacturers.

- Consumers will choose eco-friendly packaging over plastics as they become more concerned about the environmental impact of packaging.
- Most industries will use reusable packaging to reduce waste.
The world is rapidly turning toward the age of the New Normal due to the COVID-19 pandemic. Almost all sectors of society, including consumption, education, transportation, healthcare, have adopted contactless approaches, and science, technology and innovation is the key in this new transition.

The topic of KISTEP 10 emerging technologies for 2021 was selected as the 'untact (contactless) society', based on the literature review and expert opinions. KISTEP 10 emerging technologies in the untact era were selected through professional meetings and patent analysis, after analyzing technologies that are considered to be critical in the next 10 years.

Technology candidates in the field of healthcare, education, transportation, ICT, energy, and environment were first analyzed, and the technologies that comply with the topic “untact” were selected as emerging technologies.

The technology candidates were further analyzed through patent analysis, professional meetings and discussions, and the selected 10 emerging technologies are as follows:

- Cardiovascular disease management technology using non-invasive biometric information
- Level 4 self-driving vehicles for people with disabilities and the elderly
- LXP-based personalized curation technology
- Autonomous last-mile delivery service
- The intelligent edge
- Real-time collaboration platform using VR and Hologram technology
- Beyond-screen technology
- Artificial Intelligence (AI) security
- Hyper-realistic media production and broadcasting technology
- Green packaging

The 10 emerging technologies are expected to meet the demands of the future, such as providing personalized experiences, social security, and the changes in demographic structure we are experiencing due to the low birth rate and aging.

To commercialize and advance emerging technologies of the Untact era, regulatory reform from the government is required. Survey performed in this study revealed the general public’s perception on the Untact service is ‘satisfactory’, and the average technological level of the 10 emerging technology in Korea is in a ‘follower’ stage. Practical strategies need to be established through a comprehensive study on the factors hampering the advance of the 10 emerging technologies: more investment and legislative adjustment are required to create a better technological environment.

<table>
<thead>
<tr>
<th>Emerging technologies</th>
<th>Factors hampering the advance of KISTEP's 10 emerging technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular disease management technology using non-invasive biometric information</td>
<td>- The amendments to the nation’s three main data privacy laws allow a broader use of personal information, however, problems still exist as the encrypted personal information can only be accessed through specialized agencies, and the encryption using homomorphic encryption (HE) has practical drawbacks</td>
</tr>
<tr>
<td>Level 4 self-driving vehicles for people with disabilities and the elderly</td>
<td>- Currently, telemedicine services between patients and healthcare workers are not allowed by law: only healthcare workers can cooperate via telemedicine</td>
</tr>
<tr>
<td>LXP-based personalized curation technology</td>
<td></td>
</tr>
<tr>
<td>Autonomous last-mile delivery service</td>
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<tr>
<td>The intelligent edge</td>
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<td>Real-time collaboration platform using VR and Hologram technology</td>
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<td></td>
</tr>
<tr>
<td>Green packaging</td>
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</tr>
</tbody>
</table>
### IV. Conclusions and Implications

Although this study employed various research methods to reflect diverse ideas and opinions to select emerging technologies in the Untact era, the followings need to be considered for future studies:

- The emerging technologies were selected through professional meetings and surveys, but it was difficult to include perspective of diverse stakeholders.
- Although KISTEP has been selecting 10 emerging technologies corresponding to social issues of each year, the research methods have not been changed much since 2013. It is suggested to explore the following year’s S&T agendas prior to the start of the research.

<table>
<thead>
<tr>
<th>Emerging Technology</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 self-driving vehicles for people with disabilities and the elderly</td>
<td>The government continues to ease regulations on the development and operation of self-driving cars, however, a clear guideline regarding liability needs to be established to have autonomous cars on the road. An infrastructure is required to promote the use of autonomous vehicles, as senior citizens and individuals with disabilities will benefit greatly from the self-driving cars.</td>
</tr>
<tr>
<td>LXP-based personalized curation technology</td>
<td>Data standardization for students is required, and a compatibility problem with the national education information system (NEIS) exists. Digital devices for e-learning are not readily accessible in schools.</td>
</tr>
<tr>
<td>Autonomous last-mile delivery service</td>
<td>Last-mile delivery robots are being developed and tested, however, autonomous delivery robots are not allowed on the road. A clear guideline regarding accident liability is currently absent: more network and charging points are required to operate last-mile delivery robots.</td>
</tr>
<tr>
<td>The intelligent edge</td>
<td>Technology dependence increases as the equipments or software platforms are mostly provided by foreign companies. Testing core intelligent edge computing services connected to 5G network is required.</td>
</tr>
<tr>
<td>Real-time collaboration platform using VR and Hologram technology</td>
<td>The technology is not quite competitive due to its high dependency on foreign equipments for media production: current VR/AR contents are technologically immature, leading to unsatisfactory user experiences. Entering market using the technology is difficult due to a high-risk initial investment.</td>
</tr>
<tr>
<td>Beyond-screen technology</td>
<td>The technological competitiveness level of Korean software industry is 79.2% compared to the world’s leading companies; furthermore, there is a lack of human resources as well. Unstable IT industry structure limits the potential of Korean software companies in the global market.</td>
</tr>
<tr>
<td>Artificial Intelligence (AI) security</td>
<td>Low technology readiness level (TRL) inhibits the introduction of AI security in Korea. Cybersecurity data is handled by each private company, and an industry-wide standard on sharing security data does not exist.</td>
</tr>
<tr>
<td>Hyper-realistic media production and broadcasting technology</td>
<td>Hyper-realistic media is difficult to commercialize due to privacy issues and strict regulations. R&amp;D personnel is in short to meet the growing needs of online performances and broadcasting services triggered by COVID-19.</td>
</tr>
<tr>
<td>Green packaging</td>
<td>Current R&amp;D in green packaging focuses on using reusable or natural materials; regulations on classification of packaging materials need to be made based on the recyclability of the materials. Introducing carbon tax will make petroleum-based polymers less competitive in the market.</td>
</tr>
</tbody>
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Korean Edition
Published in January 2021
Edited and published by
Research Institute of S&T Innovation and Strategy, KISTEP

English Edition
Published in April 2021
Edited and Published by
Center for International Cooperation Policy, KISTEP

1339 Wonjung-ro, Maengdong-myeon, Eumseong-gun
Chungcheongbuk-do, Korea
http://www.kistep.re.kr/eng