

Technologies and Interaction Trends for Smart Home Robot Development

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Abstract

With a rapid rise in the interests in the smart home robots, the major companies in the world are making multilateral efforts to develop the smart home robots. This research is to examine the trends of the technologies and interactions that need to be addressed prior to develop any smart home robots. To do so, usable technologies and interactions in the smart home were investigated first. The technologies were then subdivided into the robot technology and the smart home environmental technology, which were gathered 23 and 15 respectively with 18 types of interactions. Then, the researches on the concepts and case studies for each investigated technology and interaction have been conducted to understand the basis. Lastly, the positioning map of the technology and interaction has been established with the technology readiness level and the technology applicability on the axes. This research is significant that it suggests the technologies and interactions that should be applied prior to develop smart home robots.

Keywords: *Smart Home Robot, Technology, Interaction, Positioning Map, Trend*¹

1. Introduction

The major companies in the world have been making aggressive investments in the field of smart home robot development lately. In the last few years, the smart home robot has been continuously announced in CES. Since the robot can control the home appliances through the communication with the user, it has been the most practical substitute as the smart home hub [1]. Companies are putting a lot of effort regarding the utilization and application of the robot and the smart home technology when developing the smart home robot. The cooperation and harmony between various technologies and the companies are critical for the smart home [2] [3], and with the robot added to them, it can cause more technical limitations to consider. Therefore, a preceding review of the applicable technologies in the smart home robot is undoubtedly necessary. Through these researches, the directions of the services and functions that are possible for the smart home robot to offer could be determined. Furthermore, because the interaction between human and robot is becoming more important like the social robot and the emotional robot [4] [5], the preceding research on the interactions between human and robot is definitely necessary.

In this research, the technologies that should be handled in advance to develop the smart home robot were examined as well as the interaction trends. To do so, the technologies and interactions that can be used in the smart home robot were investigated. The technology was

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divided into the robot technology and the smart home environmental technology. In addition, through the researches on the case studies that applied the technologies and interactions, the technology readiness level and the technology applicability were reviewed and the positioning map was created accordingly. These results lead to the suggestions on the technologies and interactions that should be applied prior to develop the smart home robot as well as the directions in regards to the smart home robot services.

2. Smart Home Robot Technology

There is a variety of technologies that are used in the smart home robot; not only the technologies that can be applied to the robot itself are found, but also the technologies that can be used in the smart home are utilized. Thus, in this research, the technologies that are usable for the robot and the environmental technologies applicable for the smart home have been researched by reflecting the latest IT trends along with the studies on the literature regarding the future technology prediction. Also, the concept understanding for each technology and case studies has been conducted. Based on these results, a positioning map of the robot technology and the environmental technology has been established with the technology readiness level and the technology applicability on the axes.

There were altogether 23 types of the smart home robot technologies and they have been divided into Sensing, Motion and Cognition as in Table 1[6][7][8]. Then, Sensing was subdivided into visual, auditory, tactile, physical weight and chemical weight sensing. The concepts and case studies for each smart home robot technology have been investigated and through these results, the technology readiness level was measured and the technology applicability for the smart home robot was verified. By using the robot technology number from Table 1, the smart home robot technology positioning map has been drawn as in Figure 1.

Table 1. Smart Home Robot Technology

Division 1	Division 2	Number	Robot Technology
Sensing	Visual Sensing	1	Visual Sensor
		2	Optical Sensor
		3	Ultrasonic Sensor
		4	IR Sensor
	Auditory Sensing	5	Auditory Sensor
		6	Sound Localization Sensor
	Tactile Sensing	7	Tactile Sensor
		8	Slip Sensor
		9	Force Sensor
		10	Temperature Sensor
	Physical Weight Sensing	11	Pressure Sensor
		12	Distant Sensor
		13	Gyro Sensor

		14	Acceleration Sensor
		15	Collision Sensor
	Chemical Weight Sensing	16	Humidity Sensor
		17	Gas Sensor
Motion		18	Locomotion
		19	Autonomous Mobile
		20	Compliance Control
Cognition		21	Deep Learning
		22	Machine Learning
		23	AI

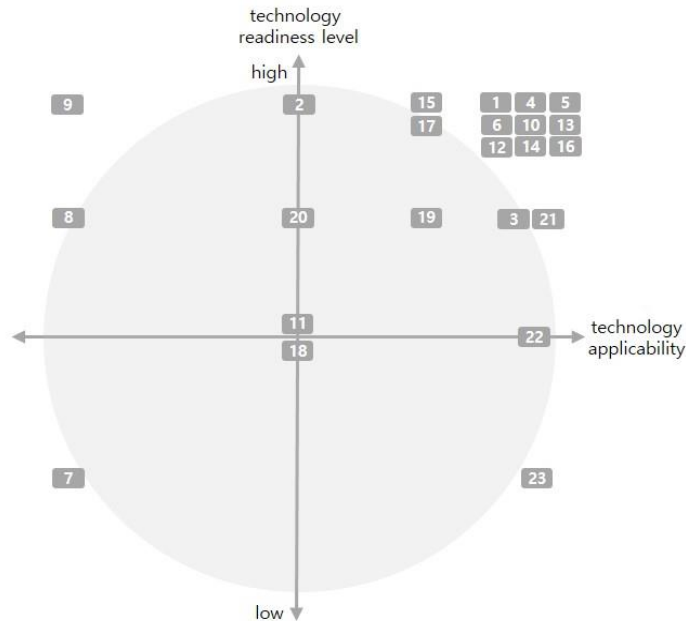


Figure 1. Positioning Map for Smart Home Robot Technology

The next technology that was examined was the smart home environmental technology and there were 15 of them as in the following Table 2. Again, the concepts and the case studies for each smart home environmental technology have been researched and through these results, the technology readiness level was measured and the technology applicability for the smart home was verified. By using the environmental technology number from Table 2, the smart home environmental technology positioning map has been drawn as in Figure 2.

Table 2. Smart Home Environmental Technology

Number	Environmental Technology	Number	Environmental Technology
1	VR	9	AR
2	Beacon	10	IoT
3	Wearable Computing	11	Wireless Internet
4	Block Chain	12	Cloud Computing
5	GPS	13	Energy Storage System
6	NANO	14	Big Data
7	Additive Manufacturing	15	Wireless Charging
8	Bionics		

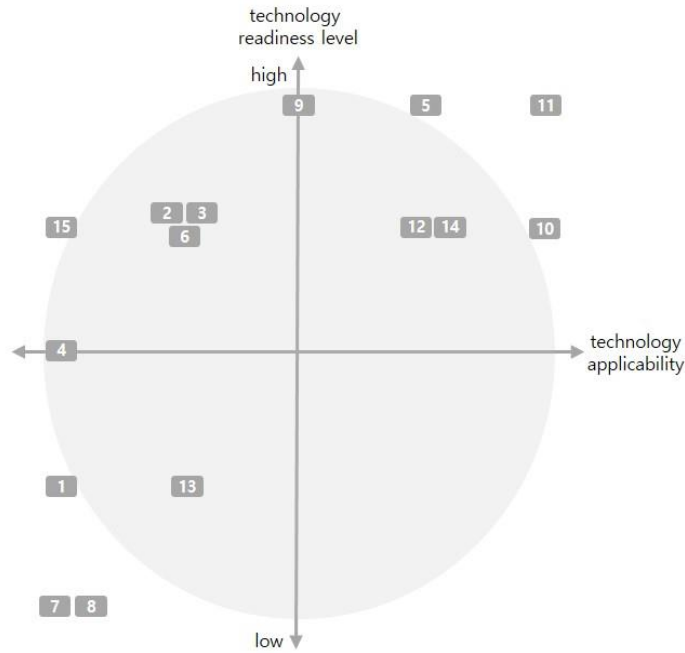


Figure 2. Positioning Map for Smart Home Environmental Technologies

3. Smart Home Robot Interaction

In order for humans and robots to interact each other, the process of perception, cognition, and expression is required. Out of these three phases, perception, which is closely linked to the robot technology, was centered to organize the interaction methods. The number of the explored interaction methods was 18 as organized in Table 3. and some of them were already being used in the robot. Plus, the concepts and case studies for these 18 smart home robot interactions have been researched to measure the technology readiness level and verify the technology applicability in the smart home robot. Also, by using the interaction number from Table 3, the smart home robot interaction positioning map has been established in Figure 3.

Table 3. Smart Home Robot Interaction

Number	Interaction	Number	Interaction
1	Vision Recognition	10	Odor Recognition
2	Pattern Recognition	11	Tactile Recognition
3	Face Recognition	12	Taste Recognition
4	Body Motion Recognition	13	Brain-Computer Interface
5	Eye Recognition	14	Heartbeat Recognition
6	Iris Recognition	15	Signature Recognition
7	Fingerprint Recognition	16	Vein Recognition
8	Auditory Recognition	17	Touch Recognition
9	Voice Recognition	18	Walking Pattern Recognition

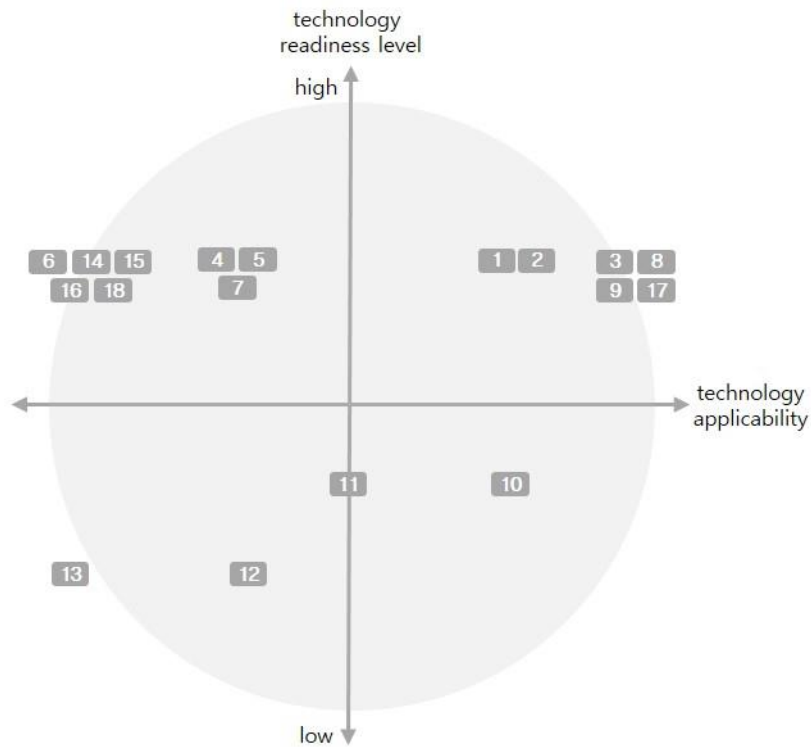


Figure 3. Positioning Map for Smart Home Robot Interaction

4. Conclusion

The objective of this research was to examine the necessary technologies that should be handled in advance to develop the smart home robot and to observe the interaction trends. So, the technologies and interactions that can be used in the smart home robot were investigated. The technology was divided into the robot technology and the smart home environmental

technology. As a result, there are 23 types of the robot technology such as visual sensor, optical sensor, ultrasonic sensor, IR sensor, auditory sensor, sound localization sensor, tactile sensor, slip sensor, force sensor, temperature sensor, pressure sensor, distant sensor, gyro sensor, acceleration sensor, collision sensor, humidity sensor, gas sensor, locomotion, autonomous mobile, compliance control, deep learning, machine learning and AI. Also, there were 15 types of the smart home environmental technology that were investigated, such as VR, Beacon, Wearable Computing, Block Chain, GPS, NANO, Additive Manufacturing, Bionics, AR, IoT, Wireless Internet, Cloud Computing, Energy Storage System, Big Data, and Wireless Charging. On top of that, 18 interaction methods were examined such as Vision Recognition, Pattern Recognition, Face Recognition, Body Motion Recognition, Eye Recognition, Iris Recognition, Fingerprint, Recognition, Auditory Recognition, Voice Recognition, Odor Recognition, Tactile Recognition, Taste Recognition, BCI(Brain-Computer Interface), Heartbeat Recognition, Signature Recognition, Vein Recognition, Touch Recognition, and Walking Pattern Recognition. Then, having the technology readiness level and the technology applicability on the axes, the positioning maps of the robot technology, the smart home environmental technology and the interactions have been created. This research is significant that it suggests the technologies and interactions that should be addressed in order to develop the smart home robot. Moreover, it can be used to propose directions in regards to the smart home robot services.

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