RESEARCH ON HUMAN'S INITIAL TRUST IN HUMANOID ROBOTS

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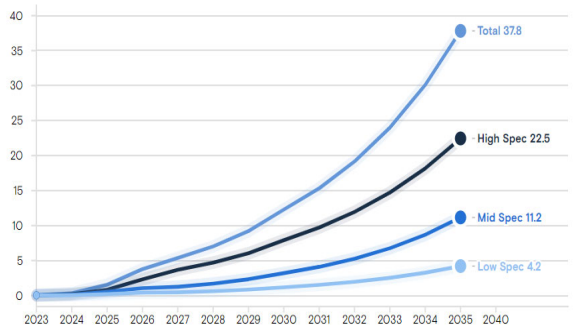
Abstract - The humanoid robot industry is expected to grow rapidly with the advent of various humanoid robots equipped with artificial intelligence. However, it is also expected that people's concerns and worries about humanoid robots, such as privacy violations, will increase. Humanoid robots continue to have deep interactions with humans, and users' dependence on these robots is growing. Therefore, this study designed the initial trust formation factors for user trust in humanoid robots. This study aims to provide strategic initial trust-building guidelines for the development of safe and effective humanoid robot services for humans.

Keywords - Humanoid Robot, Artificial Intelligence, Initial Trust, Human Robot Interaction

I. INTRODUCTION

Globally, the humanoid robotics industry is expected to grow rapidly with the advent of various humanoid robots equipped with artificial intelligence. With the emergence of ChatGPT, a large-scale learning-based generative artificial intelligence (AI) recently released by OpenAI, the rapid development of natural language-based human-AI interaction services is expected. Goldman Sachs Research estimates that the global humanoid robotics market will reach $38 billion by 2035 [1]. That's up more than six times from its previous estimate of $6 billion. It also expects robot shipments to quadruple to 1.4 million units [1].

Humanoid robots are expected to grow rapidly because big tech companies such as Tesla, Microsoft, and OpenAI are driving the development of large language models (LLMs) that support human-level communication, as well as the miniaturization and lightweighting of robot manufacturing components, which are rapidly reducing costs [2]. The cost of robotics components, from high-precision gears to actuators, is also showing signs of coming down, which could accelerate commercialization.



* ($ billion), High, mid, and low spec refer to robot sophistication, from basic functionality to state of the art

Figure 1. Forecast global humanoid robot market size [1]

These highly anticipated humanoid robots are expected to support humans in various industrial settings and everyday life, such as at home. However, there are many challenges before humanoid robots can be widely used in real-life situations, such as people's homes. For example, if humanoid robots become deeply involved in individuals' daily lives, privacy issues may arise due to the collection of environmental and user behavior data. There may also be liability issues for accidents or damage caused by the robot's autonomous behavior. This necessitates an effective approach to reduce users' rejection or anxiety toward humanoid robots and to build initial trust effectively. Therefore, this study aims to investigate the factors influencing initial trust between humans and humanoid robots in the context of user acceptance.

II. ARTIFICIAL INTELLIGENCE (AI) AND HUMANOID ROBOTS

A humanoid robot is a robot with a form like a human body, designed to replace human intelligence, behavior, senses, interaction, etc., or to provide various services in cooperation with humans. Humanoid robots are designed to have a similar appearance, behavior, and intelligence to humans so that they can interact naturally with humans. These robots, which have a human-like structure and are equipped with artificial intelligence, recognize the external environment, make situational decisions, and operate autonomously based on advanced technologies such as artificial intelligence, human interfaces, and sensor networks. A major reason why humanoid robots have been highly anticipated in recent years is the rapid development of artificial intelligence (AI) technology.

Artificial intelligence is defined as the art of creating intelligent machines, specifically intelligent computer programs, and is also understood as a sophisticated and complex technology that aims to mimic the human brain to perceive, understand, react, and learn [3]. In the past, AI was a very limited intelligence that could only derive answers under certain rules, but since 2010, deep learning technologies have been highly developed, allowing it to learn autonomously

from the data it is given to build judgment criteria. AI is an anthropomorphic process with human-like reasoning abilities that first gathers information from the outside world (including natural language) or from other computer systems or algorithms, interprets that information, recognizes patterns, derives rules, or predicts future events. Finally, it complements the decision-making system to generate and draw results, answer questions or give commands to other systems, evaluate the outcome of a matter, and achieve specific goals.

With these advances in AI, humanoid robot parts are equipped with AI systems to communicate and understand humans based on robot development language learning models, recognize their surroundings based on sensor systems, and continuously reinforce and learn to perform given tasks. The AI that operates the humanoid robot has computer vision technology that processes and understands image and video data through deep learning-based convolutional neural network (CNN) algorithms [4]. There is also reinforcement learning, where the robot learns optimal behavior through interaction with its environment. Additionally, there is natural language processing technology that processes and understands text and speech data using recurrent neural networks (RNN), long short-term memory (LSTM), and transformer models to support interactive communication with humans [4]. The AI module with these technologies is the software module that enables the robot to learn, make decisions, and adapt to its environment autonomously. On the hardware side, humanoid robots include a variety of sensors (e.g., cameras, microphones, gyroscopes, touch sensors, etc.) that help them recognize and interact with their surroundings. There is also a structural and mechatronics system consisting of the robot's skeleton, joints, and actuators that are organized like a human body and help it achieve human-like movements.

The utilization of humanoid robots is currently being successfully employed in a multitude of industries and service sectors. Tesla is preparing to use its own humanoid robot, Optimus, in its electric car production plant [5]. BMW also announced plans to use an OpenAI-funded humanoid robot (Figure 01) in the assembly process at its automotive plants [6]. These humanoid robots are expected to provide a variety of life support services (cooking, cleaning, etc.) not only in enterprises but also at home. As technology continues to evolve, humanoid robots are expected to be used in a wide range of fields (personal support, education, treatment, commercial, etc.) in the near future. For instance, Zora, a care robot developed by Belgian robotics company Zorabots, is deployed in care facilities to assist elderly individuals with rehabilitation exercises and emotional support [7]. Humanoid robots are expected to greatly change human production and lifestyles and reshape the global industrial development pattern.

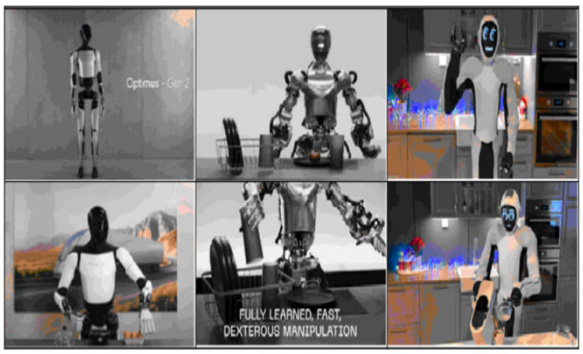


Figure2. Humanoid robots[5][6]

III. USER TRUST FOR TECHNOLOGY

The rapid development of humanoid robotics technology has raised expectations, but it has also raised concerns about robots, such as the invasion of user privacy and liability in the event of an accident caused by a robot's misjudgment. Therefore, many studies have begun to discuss the factors for effective user acceptance of AI and robotics [8][9]. The trust factor is recognized as an important prerequisite for people's acceptance of robots [10]. Trust directly affects people's willingness to accept the information provided by the robot, follow its suggestions, and utilize the advantages inherent in robotic systems. Therefore, in human-robot collaboration, trust is considered a critical factor in performance [11].

Trust is a human social concept that humans instinctively use when interacting with one another. Trust refers to a party's willingness to rely on the behavior of another party based on the expectation that the other party will perform certain behaviors expected of the trustor [12]. A person's behavior is determined by the degree of trust they have in someone or something. Therefore, trust is a key factor in all relationships involving human-to-human interaction. Trust is also a very important concept not only in organizing relationships between people, but also in various fields such as systems, technologies, and services. Especially in the case of new and innovative technologies, trust in technology plays an important role in the acceptance of new technologies by users.

In the field of technology, trust is defined as a user's evaluation of the characteristics of a technology (e.g., system functionality, service structure). The willingness to rely on a technology across situations and technologies is particularly relevant to trust in technology [13]. In technology acceptance, trust is a predictor of dependence on the technology. Low trust in a high-performing technology can lead to a lack of use of that technology, which in turn leads to high costs in terms of lost time and work efficiency. Siau

& Wang [14] found that trust in technology is largely determined by human characteristics, environmental characteristics, and technology characteristics.

Most of the previously discussed factors of trust in technology have limitations in explaining the formation of initial trust in technology by people who have no experience in using it. In addition, in humans' relationships with humanoid robots, trust is formed by perceiving the robot as human-like, which is different from other technologies [15]. Therefore, a more systematic approach is needed to develop trust between humanoid robots and humans compared to existing technologies. Especially in the case of AI technologies, the initial trust-building process is even more important, as skepticism about AI can be a negative factor in the acceptance of AI technologies [16].

Therefore, in order to build users' trust in humanoid robots, it is necessary to identify factors that support initial trust in humanoid robots among users who have not used them before. Currently, most people have no experience with advanced robotics services before humanoid robot services are activated. For a strategic approach to specifically build trust between humans and humanoid robots, it is necessary to identify factors that can help build initial trust without prior experience with humanoid robots.

IV. USER's INITIAL TRUST FOR HUMANOID ROBOTS

Initial trust is trust that is formed before any interaction or experience with the trusted party has occurred [17]. It is defined as trust that is not based on any kind of experience or direct knowledge of the other party. When people have no prior interaction, direct experience, or knowledge of the other party, they build initial trust through indirect methods [18]. In this context, "initial" refers to the first time a person meets or is influenced by another person.

Initial trust is essential for the generalization of new technologies because it can develop into cumulative trust as users encounter new innovative services or products and gain more experience and knowledge [19]. Initial trust is even more important for new technologies, where users must overcome perceptions of risk and uncertainty before they can use the technology. For consumers, new technology is something they have not seen before, so they may lack relevant knowledge about it, and the resulting fear or uncertainty may lead to resistance to adoption [20]

McKnight and Chervany [17], leading researchers on cues of initial trust, proposed a model of initial trust formation in organizations and identified disposition to trust (personality-based trust), cognitive process, and institution-based trust as the basis for initial trust. First, disposition to trust is a general tendency to trust people that is naturally formed during childhood when people ask for and receive help from caregivers. Next, they presented cognitive-based trust as trust that relies on cognitive cues or first impressions, such as a person's reputation. Finally, institution-based trust is trust that reflects the sense of security we feel about a situation due to social guarantees, safety nets, and structures. They argued that these initial bases of trust influence trusting beliefs, which in turn influence trusting intentions.

Later, Li et al. [21] further discussed the influence of benefit/cost calculation in addition to the three factors proposed by McKnight and Chervany [17] in the formation of initial trust in information systems in organizations. When people decide whether to trust a new person they encounter in a new situation, they assume that the other person is rational and calculating and will act in their best interests. They also assume that the other person will not engage in opportunistic behavior if they expect to gain less [22]. Therefore, they tend to trust the other person more when they expect to get more benefit than cost from interacting with the unfamiliar person.

Reflecting the factors of these previous studies, this study designs a model of people's initial trust formation in humanoid robot services as follows. First, under personality-based trust, we expect that a person who has formed a fundamental faith in robots since childhood through books, TV, etc., will have positive trusting beliefs about humanoid robots. Furthermore, based on personality, a trustor with a positive trusting stance is more likely to choose to trust the other person initially because they expect that a friendly relationship with the other person will have positive outcomes [18]. Therefore, we expect people with a positive trusting stance toward humanoid robots to exhibit trusting beliefs toward humanoid robots.

Under the cognitive basis, we expect that the greater the perceived social reputation of humanoid robots, the greater the trusting beliefs about humanoid robots. Next, in the institution-based trust, we first expect that people who have positive expectations of situational normality in relation to humanoid robots will have stronger trusting beliefs. Situational normality means that the situation involving the other person will be normal and that all interactions will take place in the proper order. Since humanoid robot services are built for user-friendliness, users expect the robot to have structurally normal interactions.

Next, structural assurance means that safeguards such as promises, contracts, regulations, and warranties are in place [18]. People who expect that there are safeguards such as manufacturer warranties and social safety regulations related to humanoid robot services can be expected to form trusting beliefs about humanoid robots. Finally, users who expect the cost-benefit calculation of humanoid robots to be favorable are expected to have trusting beliefs about humanoid robots.

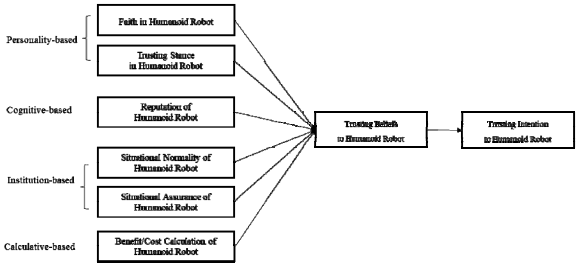


Figure 3: Initial trust for humanoid robot

V. CONCLUSION

This study designed the initial trust formation factors for user trust in humanoid robots. Based on the representative initial trust studies by McKnight and Chervany (1998) and Li et al. (2008), we examined the factors that form people's initial trust in humanoid robots. Humanoid robots continue to have deep interactions with humans, and users' dependence on humanoid robots is growing. However, it is also expected that people's concerns and worries about humanoid robots, such as privacy violations, will increase. Therefore, this study aims to provide strategic initial trust-building guidelines for the development of safe and effective humanoid robot services for humans. This study has limitations as it is still at a conceptual level. In the future, we plan to improve the model design and conduct a survey-based empirical study.

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