Title	Studies on Teleoperated Android based on Actual Person
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Citation	大阪大学, 2010, 博士論文
Version Type	
URL	https://hdl.handle.net/11094/58351
rights	
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論 文 内 容 の 要 旨

The overall motivation of this study is to find out how we can realize service robots that people can talk to seriously with respect, and at the same time, to investigate how the body works in shaping the communication and the personality.

With the advance in robotic technologies, we are now at the stage to explore requirements for much complicated tasks such as persuading or instructing people. When robots start to play advanced roles in our lives such as elderly care, attributes such as trust, reliance and persuasiveness will also be critical for performing appropriate services and roles such as doctors, teachers and consultants of mankind. For robots not just to stay close and live along with people and to communicate smoothly with people, but also for robots to be relied by people' and to perform critical jobs, robots need the impression that are required for people in the same position; that is, to provide the impression of reliability and trust. Past studies have shown the importance of humanlike nonverbal channels and the superiority of the physical presence of robots to software agents or computer terminals in everyday conversation. Researchers have been trying to make such interactive robots ``humanoid'' by equipping them with heads, eyes and hands so that their appearance more closely resembled human beings that allow robots to make movements and gestures analogous to human. These forms are not only efficient from the viewpoint of functionality but because people have a tendency to anthropomorphize in ones nature; that is, it is the human-like appearance that best help us interact with robots. However, up to now, scant attention has been paid on how appearances of service robots shall be designed. Appearance has always been the role of industrial designers and it has seldom been a field of study. Based on the psychological and philosophical results, the body in shaping the mind, or more specifically, appearance in forming impression or changing people attitude, is one dominant factor that rules human behavior. In order to robots to obtain social attributes, the effect of appearance shall be systematically examined.

In this thesis, a new robotic system *geminoid* had been developed as a platform for human-robot communication study in natural, conversational interaction tasks. In addition to its appearance

that highly resembles an actual person, a semi-teleoperation system is integrated in order to overcome the limitation of current artificial intelligence technology. First, a case study was conducted to see how people react to and adapt to a geminoid. The daughter of the geminoid source person and another child unfamiliar with the source had conversation with the geminoid and their attitudes were compared to that toward the source person. These two children form a clear contrast in their relationship with the geminoid source and have provided important insights on how people react and become adapted to the geminoid. Following the case study, two studies were held to examine how appearances of physical agents affect people attitudes and impression formation: one with persuasion tasks and another with the *ultimatum game*. Through these tasks, how appearance affect people reaction in impression formation and mentalizing were examined. The results revealed a rather complex interaction between the appearances of robots and human response, especially how the mentalization process toward physical agents are affected by the appearance of robots.

Through these studies, some issues with the current geminoid were found. In order to improve one of the major issues, the facial expressiveness of the geminoid body, a pilot study was conducted. For service robots to deal with people in a way natural to human beings, smile is one thing that robots need to recognize correctly and express appropriately. Here, using a virtual agent, whether people can perceive different types of smiles by changing simple elements of face is examined. The results showed successful distinction of smiles by temporal changes in facial movements, which lead to the development of a new geminoid robot.

The four studies shown in this thesis are only the very first step in investigating factors for effective human-robot communication. The thesis is concluded by discussing the findings as well as showing future directions to be investigated for the realization of socially acceptable service robots. Although this thesis mainly deals with the issue of appearance, the unique notion of the geminoid system, which allows the separation of the mind and the body, allows us to investigate numbers of interesting philosophical and psychological issues that were never possible before the invention of the geminoid. Based on the experience with the geminoid, some possible research topics are also discussed.

論 文 審 査 の 結 果 の 要 旨

本論文は、実在人物に基づく遠隔操作型のアンドロイド・ロボット「ジェミノイド」の開発と、これを用いた認知実験を通じて、ロボットの外観が人の印象にどのような影響を及ぼすか、サービスロボットが社会の一員として認められるためにはどのような特性を備えるべきかについて基礎的な検討を行ったものである。近年、人型のロボットを用いて認知実験を行い、そこから人の認知特性を導出しようとする研究手法が出てきているが、人の特性を明らかにするうえでも、またサービスロボットが産業化され、社会にロボットが受け入れるためにも、ロボットの外観がどのような影響を人に及ぼすかを明らかにすることは必要不可欠である。ジェミノイドと言う、これまでにない存在を開発するとともに、これを用いた認知実験を通じて人の特性を測ろうとする手法や、その研究プラットフォームとしての有用性を検証し、新たな研究分野を提案した点は興味深い。

本論文では、まずロボットに対する印象や態度を決定づける従来の研究について俯瞰するとともに、近年盛んなサービスロボットの研究の進展と、人工知能の限界について言及している。これに対する一つの解として、本論文では実在人物に基づく遠隔操作型のアンドロイド・ロボット「ジェミノイド」を提案し、開発手法について述べている。またジェミノイドの運用を通じて得られた経験から、ジェミノイドにより可能となる新たな研究分野について提案を行っている。次に、児童との長時間の対話実験を通じて、ジェミノイドの実用性を検証している。人がジェミノイドにどのように適応していくのかを検証することで、ジェミノイドが人の制御可能な代替となりうる可能性を示すとともに、ジェミノイド実装の制限を明らかにしている。これらの知見を基に、ロボットの外観がどのような影響を人に及ぼすかを認知実験を通じて検証している。また、ジェミノイド実装の問題点の一つである、顔面表情機構の改良指針について、人の認知特性を測る実験を通じて考察を行い、新たなジェミノイドロボットの実装に結び付けている。

以上のように、本論文は実在人物に基づく遠隔操作型アンドロイド「ジェミノイド」の提案・開発と、これを用いてサービスロボットが備えるべき特性について検討を行っている。また、ジェミノイの利用により可能となる、新た

な研究アプローチと研究分野の提案を行っており、これらの成果を基に今後さらなる発展が期待できる。よって本論文は博士論文として価値あるものと認める。