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論文題目	Incremental Learning from Humans through Long-term Interaction toward Generating Non-verbal Behavior of Social Robots			
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論文の内容の要旨

People use a wide range of non-verbal channels, including facial and bodily expressions, to communicate their emotions or intention during human-human interaction. Those modalities encourage the communicators' messages could be transmitted to interacting partners in a facile and transparent manner. Being echoed by the influence of human social behaviors, recent studies in human-robot interaction have investigated how to generate non-verbal behaviors for social robots in a way that is appealing and familiar to human partners.

However, non-verbal behaviors are ambiguous. The way how humans express and interpret social behaviors is highly affected by many different factors, including individual personality, cultural background, and other environmental settings. To tackle this problem, the study presented in this dissertation focuses on developing robots' social gestures to adapt to interacting partner's behaviors, allowing generated robots' gestures are familiar to the current social norm. The proposed approach concentrates on the body channel for expressing robots' emotional states and supporting semantic contents of robots' speech. To achieve that, we design the model for generating emotional gestures, the model for generating communicative gestures, and the transformation model. The suggested frameworks endow a robot with capabilities of learning from human behaviors obtained through long-term interaction and transforming generated gestures into the robot's motion, being the robot's social cues supporting for different interaction contexts. We demonstrated the proposed idea on a target social robot. A series of experiments was conducted to evaluate the designed frameworks considering the human perception of generated robot's social cues and the quality of generated gestures. The experimental results also confirmed that different users may interpret the same robot's gesture in different ways. Therefore, the problem of behavior adaption should be addressed when designing non-verbal cues for social robots.

Keywords: *social robots, human-robot interaction, non-verbal behaviors, emotional gestures, communicative gestures, imitation learning.*

論文審査の結果の要旨

This dissertation addresses the problem of generating non-verbal behavior of socially assistive robots for the expression of emotion toward enhancing user engagement and supporting long-term interaction between the user and the robot. The main technical challenge is that social cues and emotional behavior are ambiguous and affected by many socio-cultural factors such as individuals' personality traits, cultural background, and societal environment. The author proposed an incremental approach to learning by demonstration to facilitate the selection of the user's reference emotional behavior and its transformation into the robot's configuration space taking advantage of machine learning. He furthermore implemented a conditional generative adversarial network for the synchronized gestures and speech production to convey and/or emphasize a message clearly noticeable and recognizable to the user. The effectiveness of the proposed approach was verified through extensive real robot experiments, and evaluated using online surveys by several hundred participants from a variety of cultural backgrounds.

Specifically, the author developed an efficient computational framework to endow the robot with the social and emotional intelligence, associated with bodily behavior synthesized with text description. The integrated framework was implemented on a commercial off-the-shelf social robot and can be applied to a variety of robots having different kinematic structures. The proposed behavior generation models have been published in the IEEE Transactions on Cognitive and Developmental Systems and several IEEE flagship conference proceedings. In contrast to most of existing behavior generation models that rely on rule-based or theory-based approaches, this work explores data-driven approach that built on the latest findings of selective social learning in infancy, offering an autonomous behavior generation method reflecting the user's affective and habitual behavioral patterns over a long period of time. Overall, this research opens doors to impactful contributions to the social robotics and human-robot interaction community. This is an excellent dissertation and we approve awarding a doctoral degree to NGUYEN Tan Viet Tuyen.