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研究課題名（和文）Influencing human behavior with whole-body emotional humanoid robot

研究課題名（英文）Influencing human behavior with whole-body emotional humanoid robot

研究代表者

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研究成果の概要（和文）：本研究の基本的な妥当性を裏付けるものであった。社会的妥当性を裏付けるものであり、ヒューマンロボットインタラクションにおける研究成果の新しい応用方法を提案する形となった。情動的歩行に関する研究であり、感情の変化が歩容に与える影響とロボットの情動的歩行が人間に与える精神的影響に関して報告した。感情の変化が人体、特に歩容に与える影響を解析することから始まり、その結果をヒューマノイドロボットへ応用する情動的歩行のパターン生成法を考案し，実際にそれをロボットに実装し評価した。

研究成果の概要（英文）：As the emotional gait is a critical information, emotion information influences definitely the ideas humans might have about the robot such as the robot's occupation or robot's acceptance in the society. The uncanny valley effect of this research is evaluated with self-reporting questionnaire. Those experiments are controlled for the cultural background but also a different perception of emotions. This is a study of the emotional gait and its effects on the body and the mind of humans. It starts from its understanding of the change that the emotions have on the human body and on the gait, to its application of the knowledge on the body of a humanoid robot in order to influence the robot ' s human partner(s). Using emotional gaits in humanoid robots have several benefits from a better and more precise communication between humans and robots but also that an emotional gait would influence human behavior with or without a direct interaction with the robot.

研究分野：　知能機械学・機械システム

キーワード：　robot　gait　emotion

１．研究開始当初の背景

Humanoid robots have this formidable advantage to possess a body quite similar in shape to humans. This body grants them, obviously, locomotion but also a medium to express emotions without even needing a face. They are also designed to interact with people, in order to support them in their daily life, be it as soon as kindergarten or as late as nursing home. Advanced robots such as robot companions, robot workers, etc., will need to be able to adapt their behavior according to humans' feedback. For humans, our daily social interaction is based on multimodal and sometimes redundant communication channels (language, speech tone, gesture, sound, text, etc.). On a humanoid robot, all those channels are not necessarily available usually due to hardware constraints. For example, ASIMO, ATLAS and HRP-2 do not have any face and are expected to interact with humans to complete various tasks. Thus, humanoid robots should use their body and available communication channels as human-like as possible in order to deliver the correct message to its human partner. We know that emotions strongly affect social interaction and the expression of emotions is a part of multimodal communication. With emotional gestures, robots might be able to influence the state of mind or reaction of their human. Emotions, especially experienced at the time of the decision, can influence directly or indirectly the decision maker's expectation of the probability or desirability of future consequences of said decision.

２．研究の目的

We want to affect the perception of people of our robot by solely using its body. By using body movement and gait, we solve the issue when the face is not visible (which can be too far to distinguish facial features or simply has no facial expression capability) but also, we can give convey emotional messages without having the robot to directly interact with people. For example, the gait is quite influential for human predators when they choose their victims and this could be extended to robots. This result could be extended to humanoid robots in order to protect them against vandalism by appearing less defenseless when they will wander cities. We can also think about several applications of an emotional gait based on the effects on the human perception: intimidate people for law enforcing robots, calm people during disasters, or simply to ease communication and understanding of the robots' intentions during interaction with human partners.

Even if it has been shown that one of the most efficient ways of transmitting emotions is to express them with the face, emotional body language contains much information used in daily communication interaction between humans. Body language can affect the way facially expressed emotions are perceived and become an important cue to interpret the emotional message. It can also help to distinguish ambiguous facial expressions and increase certainty about the message conveyed to us. Emotion expression through body language can either be an isolated gesture or a different way of moving the body while performing an activity. Recognition of emotions in human motion alone was demonstrated by several studies. A further going study indicates that the same areas in the brain known for being activated especially by fearful facial expressions are also activated when a fearful body posture is shown with a blurred-out face. Most works done in Human Robot Interaction (HRI) regarding emotions expression focused on face-based expressions, emotional speech cues or gestures. There are only few works known to us that used human-sized humanoid robots to express emotions. Lim et al. introduced for the first time emotional walking with the robot WABIAN-RII in 2004. Among other humanoids such as ASIMO or HRP-2, only Geminoid expresses emotions and only its face is used.

However until now, the gait was not used as medium to convey information to people in the robots' surroundings or during direct interaction. The purpose of this project is to study the influence of the emotions on the human gait and how the emotional expression in the gait affects the human partner's perception of the robot and the interaction between the

robot and its partner(s). This will lead to better emotion expression ability for humanoid robots and will increase the acceptance of such emotional robots in our society. The chosen approach for this research is to first study humans (how humans express, perceive and are affected by emotions in the gait) and, then apply the earned knowledge and understanding to humanoid robots.

３．研究の方法

1. Identify how humans express emotions in their gait by using human motion capture system, understand how they perceive other humans' emotions when emotions are expressed in the gait and how humans are affected by this perception;
2. Create emotional patterns that can be used either on WABIAN-2R or KOBIAN-R and develop an emotional pattern generation system which can take as inputs an emotion and its intensity;
3. Study how emotional gaits expressed by humanoid robots can be perceived by humans and how those emotional patterns can affect interactions with humans.

４．研究成果

My research shows that emotions produced changes in the human gait: kinetics and dynamics are different when we feel happy, sad or angry. Those changes are recognized by people around us. If we apply those changes to the robot and produce similar changes in the robot gait, those changes and therefore the emotions producing them are recognized in a similar fashion than with humans. To be useful in a human society, those gaits should be socially acceptable and not inspire fear or discomfort, which was supported by the experiments. Finally, in order to facilitate the creation of such emotional gaits, I created two models: a basic quadratic model and a more complex model based on PCA and HMM.

I looked at understanding the effects of emotions expression in the context of a humanoid robot and the possibility of that robot working with or for humans. First emotions in robots, and especially expressed by gait-only, are recognizable and I achieved a similar recognition rate as it would have been for emotions in human gait. Second, emotions expressed by our biped robot affected rather positively the view of the participants: they thought the robot looked more human and more intelligent while expressing specific emotions. Despite these positive results, I wondered whether the expressed emotions might make the robot appear too human and therefore scare away users. This fear of human-like objects is described by the Uncanny valley theory. To test this phenomenon, I decided to study two different types of population: culturally-different population (French vs. Japanese) and mind-different population (Autistic vs. Non-Autistic). I found that if the users like the appearance of the robot, the Uncanny valley had a few or no effect on the acceptability of the robot as a worker. Also, persons affected by autism are much more sensitive to the Uncanny effect than non-afflicted persons, therefore we should pay attention to the robot appearance when designing new robots.

I extended the current emotion expression capability of humanoid robots by expressing emotions in the gait with the goal to better integrate them as robotic workers in our society. I proposed an innovative and general framework to create, model and assess emotional gaits for humanoid robots Hereafter I would like to present the contributions and the results achieved in this project:
I established that not only emotions but also the emotional intensities produce significant changes in the gait. Those changes are quantifiable and thus can be used to create a gait model;
I designed two different models, one specific to our robot, and another one more complex and generalizable to humanoid robots;
I created emotional gait patterns for the robot which were recognized almost as well as human emotional gaits;
I demonstrated that emotions expressed in the gait influence the perception of human observers. I also observed that the effect of the appearance prevails over the effect of Uncanny valley.

５．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

〔雑誌論文〕（計１件）査読あり

1. M. Destephe, M. Brandao, T. Kishi, M. Zecca, K. Hashimoto, A. Takanishi, "Walking in the Uncanny Valley: Importance of the Attractiveness on the Acceptance of a Robot as a Working Partner", Frontiers in Psychology - Cognitive Science 6 (204), (Impact Factor 2.8).

〔学会発表〕（計 3 件）

1. G. Enriquez*, M. Destephe*, S. Hashimoto, A. Takanishi, "A Novel Approach to Low Cost, Wide Range Motion Capture System: Validation and Application to Human Behavior Analysis", IEEE Engineering in Medicine and Biology conference 2015 (EMBC2015), Milano, Italy.

2. M. Destephe*, M. Zecca, K. Hashimoto, A. Takanishi, "Uncanny Valley, Robot and Autism: Perception of the Uncanniness in an Emotional Gait", IEEE Robotics and Biomimetics 2014 (RoBio2014), pp 1152-1157, Bali, Indonesia.

3. M. Destephe*, M. Brandao, T. Kishi, M. Zecca, K. Hashimoto, A. Takanishi, "Emotional Gait: Effects on Humans' Perception of Humanoid Robots", 23rd IEEE International Symposium on Robot and Human interactive Communication (RO-MAN 2014), pp. 261-266, Edinburgh, Scotland.

6.研究組織

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