

論文 / 著書情報
Article / Book Information

題目(和文)	柔らかいぬいぐるみロボットのための抱擁を中心とした社会的接触インタラクションの認識手法
Title(English)	Embrace-based Social Touch Recognition System for Soft-Stuffed Robots
著者(和文)	KLEAWSIRIKUL N
Author(English)	Nutnaree Kleawsirikul
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種別(和文)	論文要旨
Type(English)	Summary

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論文要旨

THESIS SUMMARY

専攻 : Department of	Computational Intelligence and Systems Science	専攻	申請学位 (専攻分野) : Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名 : Student's Name	KLEAWSIRIKUL Nutnaree		指導教員 (主) : Academic Supervisor(main)	HASEGAWA Shoichi
			指導教員 (副) : Academic Supervisor(sub)	

要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

Social touch recognition, a tool which enable robots to understand touch, is an important part of human-robot interaction cycle which can provide positive psychological benefits to humans. In this field, social touch usually includes hand-based touch gestures, such as pat and rub, and occasionally simple hugs. Embrace pose, or a different way of hugging, is also an important part of social touch with valuable psychological benefits but has not been given much attention in the touch recognition field. Therefore, this dissertation aims to create a new embrace-based social touch recognition system for stuffed-toy robots to understand and respond to touch happening during different embrace poses. Based on this goal, the social touch recognition has been proposed to include three main parts: definition of social touch, touch sensing hardware suitable for soft-stuffed robots and the social touch recognition software capable of recognizing embrace poses and touch gestures.

The first part defines the social touch types for this study. These include embrace poses and touch gestures defined based on the parent-baby holding interaction.

The second part details the hardware implementation built with comfort as the main consideration for an affectionate interaction. The touch sensing hardware consisted of 17 fabric capacitive touch sensors for sensing location and amount of touch and accelerometers for sensing dynamic hand movements. Both sensors were attached on a soft removable felt touch pad suitable for soft stuffed robot.

The last part includes software implementation of social touch recognition method which was further divided into two separated embrace and touch gestures recognition methods based on the initial observation that embrace poses and touch gestures could be characterized by different kind of information. Embrace poses require touch location while touch gestures require dynamic information.

In the embrace recognition method which is the main study of this dissertation, the system applied an unsupervised k-means clustering on the dimension-reduced equal-weighted locational-based features to recognize embrace interactions, with implication of the ability to learn embrace patterns in free interaction. The evaluation results based on ground truths shows that the embrace recognition model built based on the proposed method can recognize embrace poses from unknown participants with good performance if given a suitable number of clusters. To find this number, two additional techniques, an unsupervised class assignment method and model selection guideline were proposed. The guideline select the candidate models based on the peaks of curvature of the within-cluster distance within the range of the expected class to twice its number. The class assignment assigned classes to clusters of the candidate models based on the most common patterns found within the cluster. The candidate model given the most appropriate class assignment was then selected as the final model. The example application of these two proposed techniques shows that a model with a good performance could be achieved. In addition, it was found that different resolution and location of touch sensors could affect the recognition performance, with higher touch resolution giving higher recognition performance.

In the touch gesture recognition system, the initial study found that different touch gestures contain specific patterns in different frequency period. Based on this, the system applied a random-forest classifier on intensity-based multi-filtered of accelerometers and dynamic information from touch sensors to recognize touch gestures. The results show that while the method could obtain approximately good performance using only touch dynamic information, the best performance could be achieved when using the

dynamic information from both sensors.

In summary, the proposed social touch recognition system based on soft fabric based touch pad and software implementations of two separated embrace recognition methods were effective for the soft-stuffed robot and included several advantages. The touch sensing hardware was simple and removable and could be easily adapted on different stuffed-toy robots. The application of unsupervised approach in embrace pose recognition and cluster-to-class assignment also helped to facilitate the learning process without the need for ground truths which usually are ambiguous and time-consuming to obtain. Additionally, the proposed model selection guideline could be flexibly applied on different target populations to help to conveniently select the model. Despite these advantages, there were also limitations. First, the embrace pose recognition had the problem in differentiating similar touch poses with different robot's alignment. Second, the system still required ground truths for training touch gesture recognition models which made creating the system partially complicate. Third, the hardware has limited resolution and touch coverage which partly affected the performance. Future works include the improvement on both software and hardware and the generation of robot responses to complete the interaction cycle.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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