論文 / 著書情報
Article / Book Information

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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	知能システム科学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
学生氏名： Student's Name	武　淑琼	指導教員（主）： Academic Advisor(main)	長橋　宏
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Hand detection plays a prominent role in gesture recognition systems. There are many approaches for detecting hands. These approaches can be roughly divided into two categories. One is device-based and another is vision-based. Device-based methods detect hands based on the data obtained from some specific devices such as data gloves, sensors, Kinect, and so on. In this case, hands positions can be detected correctly. However, wearing specific devices may cause troublesome and uncomfortableness. Furthermore, processing massive data from these devices could lead to a large amount of calculation. By contrast, vision-based techniques process 2D images captured by cameras. They are more natural and suitable for real-time applications compared with device-based methods. Nevertheless, it is difficult to detect hands positions precisely by utilizing only 2D information.

Among many vision-based hand detection approaches, AdaBoost combined with Haar-like features (Viola-Jones method) is widely used in object detection due to its robustness and efficiency, and it has achieved considerable success in face detection. However, it is difficult to apply this technique to hand detection because hands are highly deformable. For each hand shape, many training instances are required. Thereby, a tremendous training set is necessary for handling many hand shapes. Moreover, false positive rate of the trained hand detector is high since hand training instances must contain background part that degrades the classification performance.

To solve these problems, we propose a novel hand detection system which copes with 27 hand shapes. Differently from the traditional hand detection systems which train one detector to cope with one hand shape, our proposed system can use one hand detector to cope with 27 kinds of hand shapes. Moreover, our trained hand detector can run in real time with high accuracy. Our system is based on a new proposed AdaBoost variant Penalized AdaBoost. Penalized AdaBoost is based on Gentle AdaBoost. Nevertheless, it reduces the generalization errors more than Gentle AdaBoost by penalizing the reduction of small classification margins. Furthermore, our hand detection system combines a new skin color segmentation technique with motion filtering to reduce the number and background noise of training data. The new skin color segmentation technique, which we call Background-masking, utilizes the geometrical information of face to remove the non-skin-color part in both training and detection. The process of our proposed system is as follows: first we do background masking for training instances, and then we utilize the background-masked instances to train the face and hand detectors respectively based on Penalized AdaBoost. Then, in detection, we detect the face, and implement skin color segmentation for test images by combining background masking, the information of detected face, and motion filtering. Finally we use

trained hand detector to detect hand in skin-color-segmented test images. Our proposed novel hand detection system, which based on Haar-like features, background-masking, motion filtering, and Penalized AdaBoost, is proved more robust against background change, rotation, illumination change, and skin color obscure than Viola-Jones method by experiments. The experiments also showed that Penalized AdaBoost is more robust than other AdaBoost variants in hand detection.

The novel contributions of our research are listed as follow:

1) We proposed background-masking which introduces a new training style for machine learning methods. It utilizes the background-masked hand instances instead of 2D hand images. Background-masking removes the background part of training instances. Thus, it can avoid the influence of background noise. On the other hand, instead of using training instances in diverse backgrounds, we can create the background-masked instances from hand images in only one background. Therefore, background-masking decreases the number of training instances effectively.

2) We proposed Penalized AdaBoost to improve the classification performance of our detection system. It penalizes the misclassification of small-margin instances in the current loop by analyzing the margin distribution in the previous loop. Furthermore, it reinitializes the weights of noise-like instances to reduce their influence on the training. Our experiments show that Penalized AdaBoost is more robust than other AdaBoost variants. As a new machine learning approach, Penalized AdaBoost not only achieves high performance in our detection system, it can also be applied to improve the classification performance of other systems.

3) We proposed a novel face-hand detection system which is a combination of Haar-like features, background-masking, motion filtering, and Penalized AdaBoost. Our experiments show that this detection system can run in real-time, and is robust to scale change, illumination change, background change, and rotation.

4) We also proposed another AdaBoost variant which we call Parameterized AdaBoost. Although it is not related to our detection system, it proves a new theory that the decreasing of training error can be speed up by reducing the sum of sample weights explicitly.

5) We analyzed the generalization abilities of many AdaBoost variants. Differently from other comparison studies, our work compares the generalization abilities of different AdaBoost variants by analyzing the weak hypotheses and margin distributions. Our comparison shows statistical proof to explain why this variant is better than that one. Our study is useful for researchers who want to improve the performance of their applications by switching to another AdaBoost variant.

In general, our research not only contributes to face and hand detection in gesture communication systems, but also contributes to the field of artificial intelligence.