論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Online boosting algorithm based on two-phase SVM training and its application to image processing
著者(和文)	ﾕｺﾞﾌﾌｼｴｳｵﾛﾄﾞ
Author(English)	Vsevolod Yugov
出典(和文)	学位:博士(学術), 学位授与機関:東京工業大学, 報告番号:甲第9346号, 授与年月日:2013年9月25日, 学位の種別:課程博士, 審査員:熊澤　逸夫,羽鳥　好律,佐藤　誠,長谷川　修,小尾　高史
Citation(English)	Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第9346号, Conferred date:2013/9/25, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	物理情報システム　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（学術）
学籍番号： Student ID Number		指導教員（主）： Academic Advisor(main)	熊澤逸夫
学生氏名： Student's Name	Yugov Vsevolod	指導教員（副）： Academic Advisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The following paragraphs briefly describe the contents of the thesis:" Online boosting algorithm based on two-phase SVM training and its application to image processing"

In the introduction, we briefly state the need and motivation of our research. We describe the current state of the art techniques for the SVM training and boosting, and show some of their drawback that we aim to address by introducing our method. We then briefly outline our algorithm and its relation to the previously described algorithms. We further describe possible applications of our algorithm, particularly in the field of image processing.

In the second chapter, we discuss related works in the field of both online and offline classification, including such well-established algorithms as AdaBoost and SMO for the SVM training, as well as their online extensions. We also include brief overview of the methods developed for specific applications, in particular, real-time object tracking. We show several drawbacks of many online methods, that is, reliance on a large number of simple features which increases the computational and storage cost, and limited number of selected classifiers, limiting flexibility. The classical methods for non-linear classifications, such as kernel based SVM, are more flexible, but suffer from the rapidly increasing number of kernel expansion terms degrading its performance. In comparison, our method combines online SVM training and boosting, resulting in an aggregate classifier which can be calculated with high efficiency and has accuracy similar or higher to that of converged kernel-based SVM. Its efficiency and flexibility allows us to implement it on the mobile device using the parallel processing afforded by the GPU, which is not feasible for most other methods.

In the third chapter, we give a detailed description of our classification method. Our method is based on the previously described online SVM training methods, such as NORMA and Pegasos. These methods are based on the stochastic gradient descent, similar to the well-known backpropagation algorithm. The bounds on the convergence speed on these algorithms are well defined in the corresponding articles. Furthermore, our algorithm utilizes the similarity between linear Support Vector Machines and boosting, and trains a sequence of the linear SVM by substituting AdaBoost greedy algorithm by the online SVM training solution. To

further enhance efficiency, each subsequent SVM in the aggregate classifier is trained based on the weights provided by the classification results of a current aggregate classifier. We use the loss function calculated during the training step on the aggregate classifier to reduce computational costs. Several experiments show that using such weighting solution is necessary for increased accuracy. In this chapter, we also give several results of comparison between our algorithm and other similar training techniques, showing that our algorithm outperforms traditional kernel-based algorithms for nonlinear classification, as well as the fact that replacing a greedy algorithm with fully interactive one may give our method better flexibility compared to AdaBoost even in the offline setting.

In the fourth chapter, we describe the application of our method to the object tracking task on the mobile device. Our approach is somewhat similar to the online boosting approach for image tracking, however the while the constraints of the mobile device render such methods impractical, we show how it is possible to get real-time high accuracy tracking solution by applying our method to simplified image features and leveraging the parallel processing on GPU.

There are several difficulties in using mobile device GPU for parallel computations. While the newer mobile devices allow the use of programmable graphics pipeline(specifically, vertex and fragment shaders), they do not allow usage of high-precision textures or multiple outputs. Therefore, the most effective features are such that can fit into a single output (32-bit), which severely limits applications of most features traditionally used for tracking , such as Haar-like features or color histograms. Also, for maximum efficiency the selected features should limit the access to the neighboring texture fragments. For the above reason, we have selected the simplified 4-bin Local Binary patterns histograms, calculated over a fixed area rectangles of 8x8 pixels. Such features have the maximum value well suited to the available accuracy and can be efficiently calculated in just 2 passes with 8 texture accesses each. Experiments to establish the discrimination power of these features show that, with the application of our training method, the accuracy is sufficient for object tracking.

We then note the similarity of the proposed features to the binary Ferns used for keypoint classification. This allows us to show how the proposed method can be used to enhance existing classification methods. By employing boosting properties of Support Vector Machines we develop a method using a combination of SVM and Ferns for texture recognition. The resulting algorithm keeps simplicity and scalability of original Ferns and achieves the increase in accuracy for lower number of features. We then implement the described method on the mobile device under the same hardware limitations as described above. The resulting implementation can achieve real-time processing of 640x480 video feed while maintaining an acceptable degree of accuracy.

The fifth chapter includes evaluation of the performance and computational efficiency of the other algorithms available for both classification and tracking, applied in both the original framework described in the founding papers and the limited resource framework

described in our paper. We compare the performance of Pegasos, NORMA and AdaBoost on the selected image features and some publically available datasets that are large enough to validate the usage of the online training methods. We also investigate the implementation of Online boosting algorithm for object tracking, and show that algorithm exhibits significantly lower computational and storage requirements while giving the comparable accuracy.

Finally, the sixth chapter contains the conclusion to our thesis.

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 2 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 2 copies of 800 Words (English).