Electronic Letters on Computer Vision and Image Analysis 13(2):22-23, 2014

Approximate Ensemble Methods for Physical Activity Recognition Applications [1]

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Date and location of PhD thesis defense: 3 November 2011, University of Barcelona

Received 31st January 2014; accepted 25 May 2014

1 Premises

"*I'm losing my mind … Each day that passes I forget more and remember less. I don't have Alzheimer or even brain damage. I'm just aging*" [2]. With these words starting his book, Gordon Bell, a luminary of the computer era, is the first person attempting to digitalize his life. He wore an automatic camera, an arm-strap that logged his biometrics and he started recording phone calls. The wonder of his technology is the new capability to find the desired information in the large amount of data stored: he started a technological revolution that will accomplish a transformation in the way humans think about the meaning of their life. But Bell's words focus on an important social concern: aging. European population is getting older and the prevalence of health problems and chronic illnesses will affect how people live, their mobility and social relationships. In this context, new computational paradigms like Ubiquitous Computing, play an important role in the development of personal health-care technologies. Body Area Networks (BAN) are object of discussion of this work. BAN devices are interconnected sensors and actuators in-body, on-body or wearable perceiving the state of the user and her surroundings. Some devices have only the capability to store a small batch of raw data and sending it to a gateway. Other devices are powerful enough to locally process the gathered data and to provide useful support to the user. These aspects highlight a key point: BAN devices can learn from the users and react in a smart way. Nevertheless, the majority of Artificial Intelligence and Machine Learning techniques running on BAN devices are methodologies usually developed for desktop computers. Some of these techniques still remain useful but others are difficult to be adapted to the specific limited hardware resources of BAN devices.

2 Main Contributions

This thesis focuses on finding computational methodologies able to reduce the degree of complexity of learning algorithms. The technique of Random Projections, able to reduce the complexity of many geometrical and probabilistic algorithms [3], is considered for generating diversity in classifiers ensemble and reducing the dimensionality of the learning problem. Two supervised learning algorithms for binary and one-class classification problems are proposed, the former called *RpBoost*, the latter *Approximate Polytope Ensemble*. Based on

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Recommended for acceptance by <Alicia Fornes and Volkmar Frinken>
ELCVIA ISSN:1577-5097
Published by Computer Vision Center / Universitat Autònoma de Barcelona, Barcelona, Spain

a boosting ensemble strategy, RpBoost fits weak classifiers on training data projected in random spaces. The approach performs better than typical boosting approaches on both synthetic data and real world problems. Results show that projections drawn from a Normal Distribution provide best results in comparison to other type of projections. The Approximate Polytope Ensemble (APE) is proposed as a new methodology for one-class classification problems. APE models the boundary of the target concept using a Convex-Hull which expansions or contractions avoid over-fitting and allow to set the optimal operating point of the classifier. The high computational complexity needed for building the Convex-Hull in very high-dimensional spaces is reduced using the Random Projection technique. The original multi-dimensional Convex-Hull is approximated projecting data to very low dimensional spaces. In those spaces, building the convex hull and checking if a point lies inside the polygon are well know problems with very efficient computational solutions. The Non-convex Approximate Polytope Ensemble (NAPE) is also proposed to cope with non-convex classification boundaries. Experimental results show that APE and NAPE represent a powerful methodology for one-class classification problems, being competitive and most of the times outperforming the state-of-the-art methodologies for one-class classification. The low computational complexity of training and testing makes APE suitable to be used in systems with limited computational resources.

BeaStreamer, a new wearable computing platform, has been developed for carrying out experiments on physical activity recognition applications. BeaStreamer senses the environment using a standard low-cost webcam and monitors user activities with a wearable accelerometer. It provides feedback to the user with audio and visual information. Using BeaStreamer, physical activity data are gathered from different subjects and successfully recognized using standard machine learning algorithms. Particularly for motion data, a new set of features is proposed as optimal feature set for activity recognition purposes providing at the same time physical understanding to the quantities involved in the classification process. A new technique that uses gait patterns is proposed as a unobtrusive authentication method. The technique is composed by a two stages machine-learning pipeline where in the first level a personalized activity recognition classifier discriminates walking patterns of the authorized user in a very highly selective way. The second stage performs the user verification task using as core technique the APE methodology. A layered architecture designed around the APE algorithm provides robustness to outliers and take into account the temporal consistency of walking activities, making the technique suitable for application in real world scenarios. A dataset of walking activities from 20 subjects walking on different environments, monitored by a wearable accelerometer and a smart-phone, has been collected for testing the proposed techniques. Results obtained show that the system achieves high performance in terms of False Acceptance and False Rejection rates, improving considerably performance of state-of-the-art techniques found in literature.

The evidence that people can be modeled by their walking patterns opens a door towards biometrics authentications that allow constant verification mechanisms. This fact, consonant with the increasing human-computer symbiosis every day more knit, will bring to new forms of interactions that, under the Ubiquitous Computing guidelines, will allow us to extend and augment our perception as originally aimed by the first wearable computer applications.

References

[1] Pierluigi Casale, *Approximate Ensemble Methods for Physical Activity Recognition Applications*, University of Barcelona, 2011. *ISBN: 9788493835163*

[2] Gordon Bell, Jim Gemmel, *Total Recall: How the E-memory Revolution Will Change Everything*, Dutton, 2009. *ISBN: 9780525951346*

[3] Santosh S. Vempala, *The Random Projection Method*, DIMACS Series, American Mathematical Society, 2004. *ISBN: 9780821871072*