Classifying Agitation in Sedated ICU Patients.

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***Abstract*—Agitation is a serious problem in sedated intensive care unit (ICU) patients. In this work, standard machine learning techniques working on wearable accelerometer data have been used to classifying agitation levels achieving very good classification performances.**

I. Introduction

Agitation is a serious problem in sedated intensive care unit (ICU) patients, especially when agitation levels are likely to bring the patient to unconsciously pull at tubes or catheters or trying to climb out of bed. Different levels of agitation are hardly quantized in Sedation-Agitation Scale, reported in Table I. Accelerometer are devices that measure proper acceleration, the acceleration experienced relative to freefall. Single and multi-axis models are available to detect magnitude and direction of the acceleration as a vector quantity, and can be used to sense orientation, acceleration, vibration shock, and falling. Miniaturization allows to use such devices as wearable sensors, opening new interesting research fileds related to human motion monitoring. In this work, two 3-axial wearable accelerometers placed on the wrists, have been used to collect data in sedated ICU patients. Standard supervised learning techiques have been used for classifying agitation levels from accelerometers data.

Score	Term
6	Dangerous Agitation
5	Very Agitated
4	Agitated
3	Calm and Cooperative
2	Sedated
1	Unarousable

TABLE I
Sedation-Agitation Scale

II. Methodology

Data have been collected from four patients. During the acquisition time, a nurse labeled manually the agitation levels of the patients. In Fig. 1 and Fig. 2, accelerometer data are reported, with labels superimposed. In Fig. 1 accelerometer data related to Level-3 and Level-4 are shown. In Fig. 2 accelerometer data related to Level-3 and Level-4 are shown.
From accelerometer data, the following features have been extracted for both arms :

- Mean Value;
- Standard Deviation ;

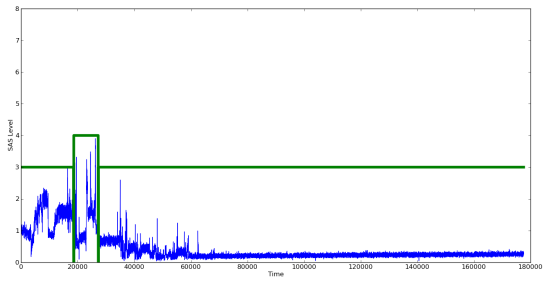

Fig. 1. Accelerometer Data for Agitation of Level-3 and Level-4. Labels are superimposed in green.

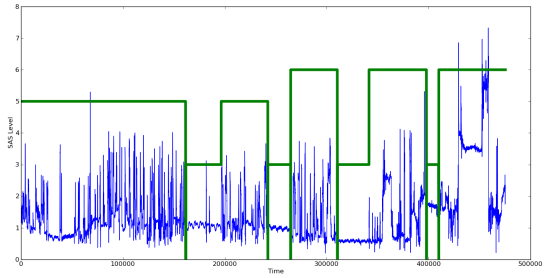

Fig. 2. Accelerometer Data for Agitation of Level-5 and Level-6. Labels are superimposed in green.

- Subband Energy of 3-Level Wavelet Decomposition Coefficients, using DB10 Mother Wavelet ;
- Derivative of Gaussing ;
- Gabor Filter with different frequencies.

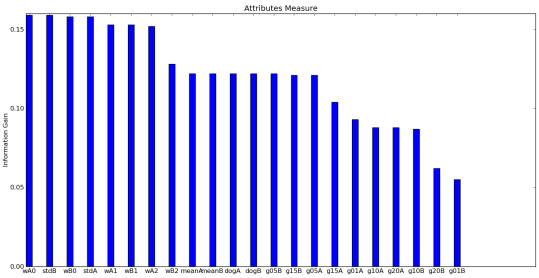

Fig. 3. Attribute Measure using Information Gain.

A measure of attributes importance has been obtained using information gain. The results of the measurement process are shown in Fig. 3. Standard deviation, subband energy of wavelet and mean values are the best attributes choosen. Finally, a 10-dimensional feature vector is used for classification.

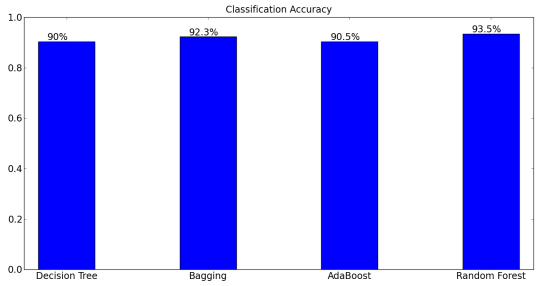

Fig. 4. Classification Accuracy for Different Classifiers.

III. Results

Dicision Trees [1], Bagging [2], Adaboost [3] and Random Forest [4] have been used for classification. In Fig. 4, classification accuracy for Level-3 up to Level-6 are shown. No data have been labeled for Level-1 and Level-2. Accuracies are above 90% for all classifiers. In Fig. 5 and Fig. 6, precision and recall for all classifiers and all agitation levels are shown. In Table II, the confusion matrix obtained with Random Forest

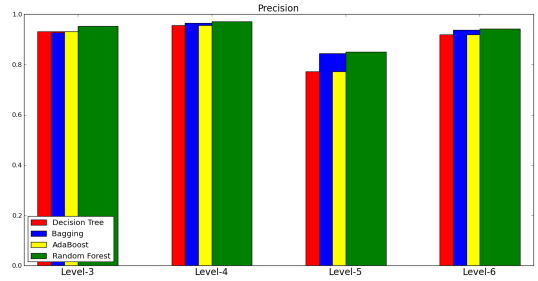

Fig. 5. Precision of Different SAS Levels for Different Classifiers.

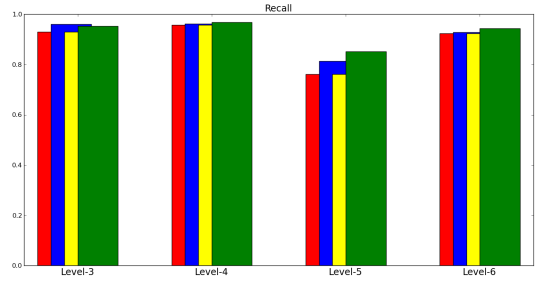

Fig. 6. Recall of Different SAS Levels for Different Classifiers.

is shown. It has to be noted that the biggest confusion is present between Level-5 and Level-6.

	Level-3	**Level-4**	**Level-5**	**Level-3**
Level-3	**1486**	81	519	489
Level-4	94	**5821**	67	105
Level-5	562	61	**6401**	1279
Level-6	454	118	1417	**22563**

TABLE II
Confusion Matrix obtained using Random Forest.

IV. Discussion and Conclusions

All the classifiers achieve good classification accuracies above 90%. The best classification accuracy is provided by Random Forest. Furthermore, all the classifiers achieve good precision and recall for all agitation level classified. These performances are slightly worst for Level-5, class having the biggest confusion against Level-6. The confusion is mostly due to the manual labeling process, where nurses labeled agitations that might seem dangerous as both Level-5 and Level-6. This fact is evident in Fig 2 where the last three labels are all set to Level-6. From accelerometer data, it is evident that only the last part might be considered a "real" Level-6. In this part, acceleration values are higher than in other segments, including those labeled as Level-6. Finally, accelerometers provide very important information related to the agitation level of sedated ICU patient. Future works in both hardware and software are intented to exploit this research line in an comprehensive way.

Acknowledgment

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References

[1] L. Breiman;J. H. Friedman,R. A. Olshen,C. J. Stone,*Classification and regression trees*, Monterey, CA: Wadsworth & Brooks/Cole Advanced Books & Software, 1984.
[2] L. Breiman,*Bagging predictors* Machine Learning 24 (2): 123140, 1996.
[3] Y. Freund, R. E. Schapire,*A Decision-Theoretic Generalization of on-Line Learning and an Application to Boosting* 1995
[4] L. Breiman,*Random Forests* Machine Learning 45 (1): 532,2001.