Development of an Algorithm to Detect Nocturnal Scratch in Atopic Dermatitis Patients using ActiGraph LEAP Devices

Matthew R Patterson[2], Sylvain Zorman[2], Maxime Chauvineau[1], Anis Aloulou[1], Damien Leger[1] & Christine Guo[2]
[1]*Hôtel-Dieu*, 1 Parvis Notre-Dame - Pl. Jean-Paul II, 75004 Paris, France
[2]*ActiGraph, L.L.C., Pensacola, FL*

Corresponding author: matthew.patterson@theactigraph.com

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Introduction

- Nocturnal scratching is a significant problem for atopic dermatitis patients because it increases the size of lesions on the body and drastically reduces sleep quality and thus quality of life for patients [1, 2].
- Treatments to reduce nocturnal scratching can be difficult to assess due to the inability of scratch questionnaires to accurately reflect how much nocturnal scratching has occurred [3].
- There is a need to objectively measure nocturnal scratch in atopic dermatitis patients to more effectively determine which treatments help patients most
- In this work, we propose an algorithm to detect nocturnal scratching using tri-axial acceleration data from two wrist based ActiGraph LEAP devices

Objective

This study aims to develop a machine learning algorithm to detect nocturnal scratching in atopic dermatitis patients with wrist accelerometers

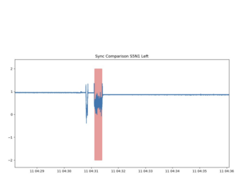
Methods

- **Setting:** Sleep laboratory
- **Devices:** Two LEAP devices (ActiGraph, L.L.C. , Pensacola, FL) and one thermal camera (FLIR A-400)
- **Procedures:**
  - Participants spent two nights in a sleep laboratory while being recorded with a thermal camera
  - An ActiGraph LEAP device was worn on each wrist
  - Tri-axial acceleration was recorded on the LEAP devices at 32-hz

Table 1: Demographic characteristics of study participants

Condition	n	age (years)	height (inch)	weight (lbs)	sex
Atopic dermatitis	7	35.8 (12.7)	65.4 (6.1)	170.7 (38.3)	4 female

Reference Data



Scratch annotation: Two raters annotated the thermal videos to determine the start and the end of each scratching bout.
Scratch arbitration: An expert arbitrator rectified any differences between the two original annotators.
Synchronization: Scratch annotations and acceleration data from the LEAP device were synchronized.

Data processing

A random forest binary classifier was trained to predict scratching on 3-second windows in which movement was present. The model was tested on a leave-one-patient-out training and testing strategy.

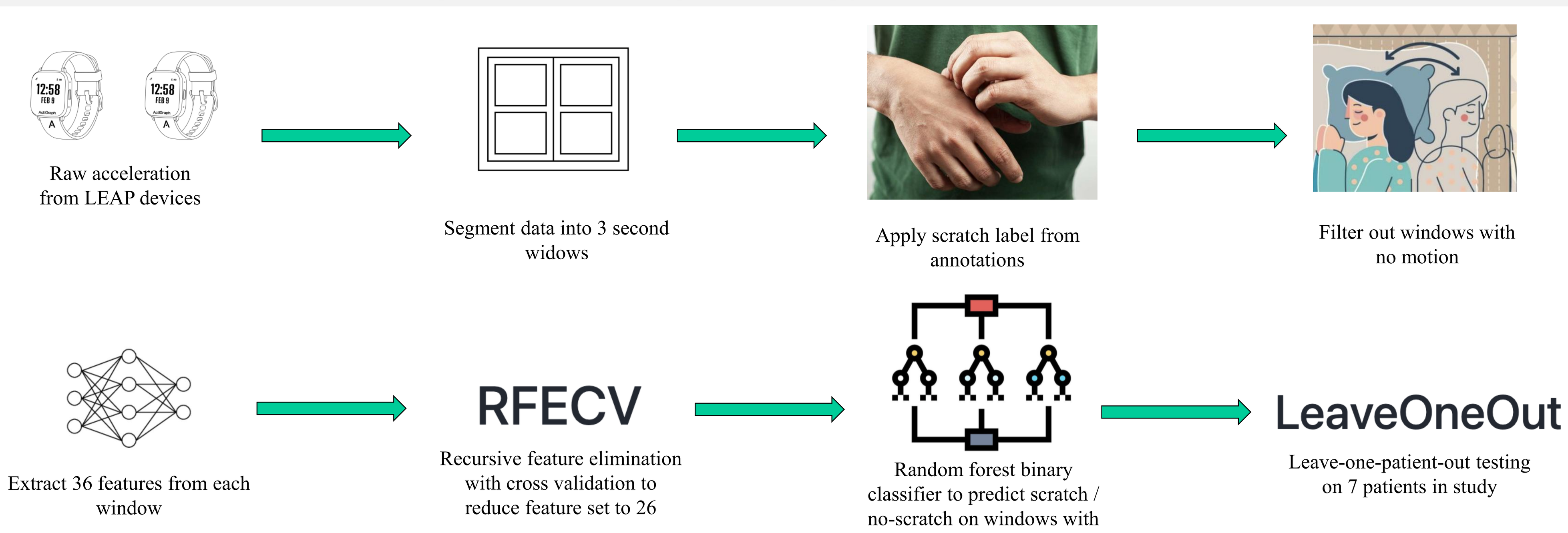


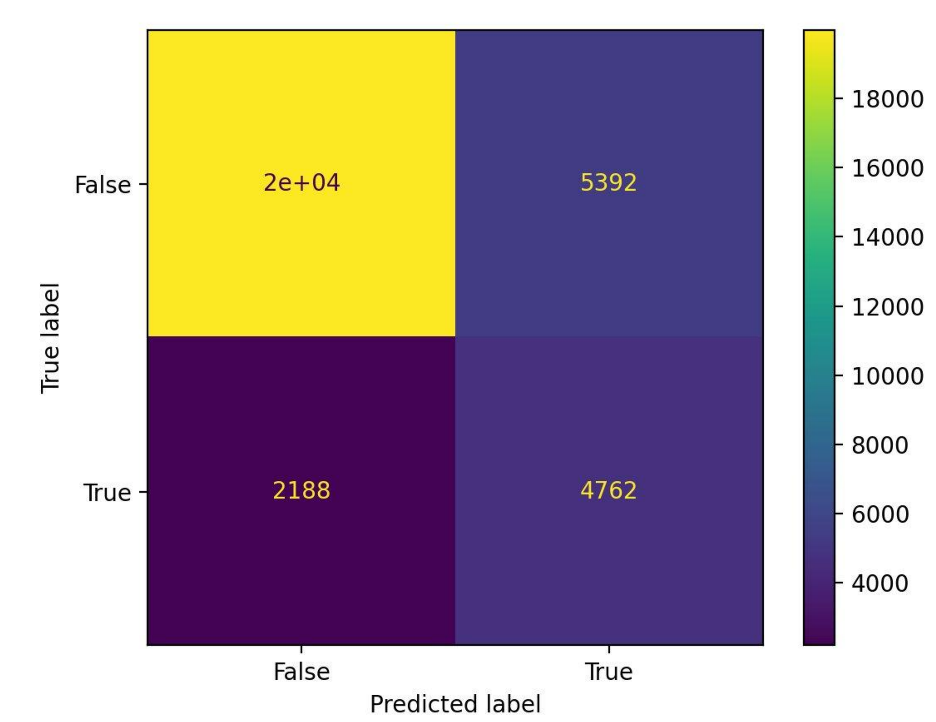
Fig 1: Data processing steps to prepare data, train algorithm and test algorithm

Results

Table 2: Performance results of the leave-one-patient-out testing strategy.

Patient	F1	Precision	Recall	Accuracy	Specificity	NPV	True scratch (min)	Predicted scratch (min)
1	0.19	0.12	0.53	0.84	0.86	0.98	4.05	18.65
2	0.42	0.38	0.48	0.86	0.9	0.93	22.95	29.10
3	0.5	0.43	0.59	0.78	0.83	0.9	41.15	56.75
4	0.65	0.56	0.79	0.77	0.76	0.9	42.80	60.50
5	0.52	0.55	0.49	0.8	0.89	0.86	43.05	38.15
6	0.57	0.44	0.8	0.74	0.72	0.93	37.90	68.20
7	0.59	0.49	0.74	0.7	0.68	0.87	155.60	236.35
Mean	**0.49**	**0.42**	**0.63**	**0.78**	**0.81**	**0.91**	**49.6**	**72.5**
Std	**0.15**	**0.15**	**0.14**	**0.06**	**0.09**	**0.04**	**48.9**	**74.4**

Fig 2: Confusion matrix results of random forest binary classifier (Predicted label) identifying scratch (True) or no-scratch (False) compared to scratch identified from expert video annotations (True label).



Discussion & Conclusions

- ❑ Model performance in line with published literature ([4] F1 = 0.39, Recall = 0.58).
- ❑ Visual analysis of synchronization indicated good time agreement between the video annotations and the raw sensor data, with only 0.74% of scratching being removed after motion filtering (compared to 10.09% previously reported in [4]).
- ❑ These results suggest that nocturnal scratch can be accurately estimated with the ActiGraph LEAP device on each wrist while atopic dermatitis patients sleep.
- ❑ Further research is on-going with adolescent patients and psoriasis patients.

Acknowledgements

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References

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