The Rise of Artificial Intelligence in Sleep Medicine is Already Here

Nox Medical is Leading the Way

Artificial intelligence (AI) is simply a software that is capable of learning from data and then using that learned information to automate a cognitive task. It's already shaping the way that sleep labs operate across the world.

Data scientists at Nox Medical are at the forefront of this sleep medicine-AI movement as they are dedicated to developing new algorithms to dig deeper into our understanding of sleep disorders to improve care for patients. At the forefront of this work is Nox Medical's Noxturnal sleep software, an AI-driven program that is fine-tuned and sharp enough to help human sleep technologists do their jobs with more ease—delivering diagnostic care to patients as fast as possible — without compromising accuracy.

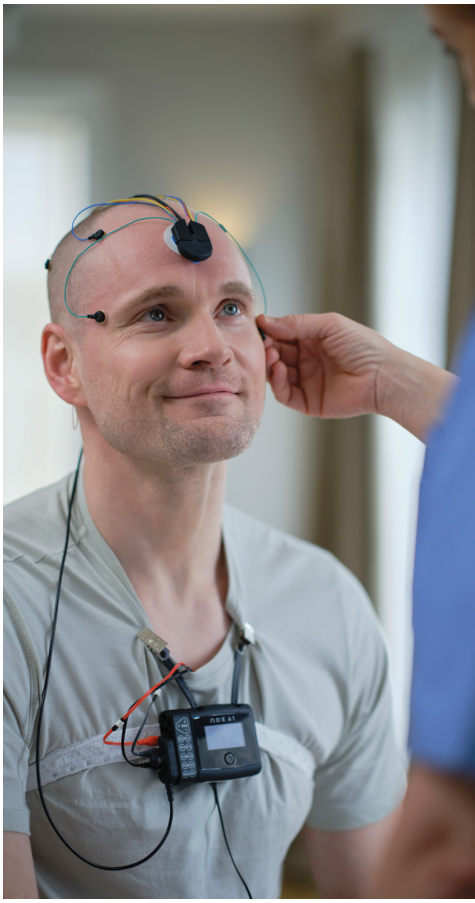
AI by High-caliber Data Scientists

At Nox Medical, our cutting-edge AI medical devices showcase superior performance, powered by a remarkable team of experts. We understand the pivotal role of high-quality data, which is why our advanced sleep software, Noxturnal, collaborates seamlessly with the pristine datasets collected using our top-notch recorders during routine procedures.

At Nox, we have pioneered the development of AI medical software. We first released a deep learning neural network in the Noxturnal sleep software in 2016. Since then, the software has evolved, become more refined, and been backed by multiple research studies. Since 2015, Nox Medical has submitted to industry competitions and collaborated on several research projects to validate its products and to establish access to extensive data. The company reached a major milestone and placed second in global AI competition by PhysioNet.org in 2018 and has since then built on the processes to detect cortical arousals.

The AI team at Nox Medical uses data from diverse geographic regions to validate their AI algorithms. This is an important step in the validation process as this indicates how the AI model will perform in the real world when it encounters data from sources it has not encountered before.

As part of these efforts, Nox is actively and continuously performing clinical validation, working with regulatory bodies and consulting with industry stakeholders to ensure all Nox products are safe and effective for patients.



AI Revolution with Solid Validation

Today, Noxturnal is included with all Nox Medical diagnostic technology, including the Nox A1s polysomnography system and the Nox T3s home sleep apnea test. The software incorporates a wide range of AI algorithms, including sleep staging, apnea hypopnea index (AHI), and periodic limb movement.

Overall, our hope is that each patient will reap the biggest benefits from AI-powered diagnostics. AI-based tools offer more automation, affording physicians and technologists the gift of time — meaning more quality face time with their patients and allowing them to spend more time analyzing rare or difficult cases to provide better and more personalized treatment.

By lowering the cost of data collection and analysis, physicians have the time for more structured assessment of treatment effectiveness.

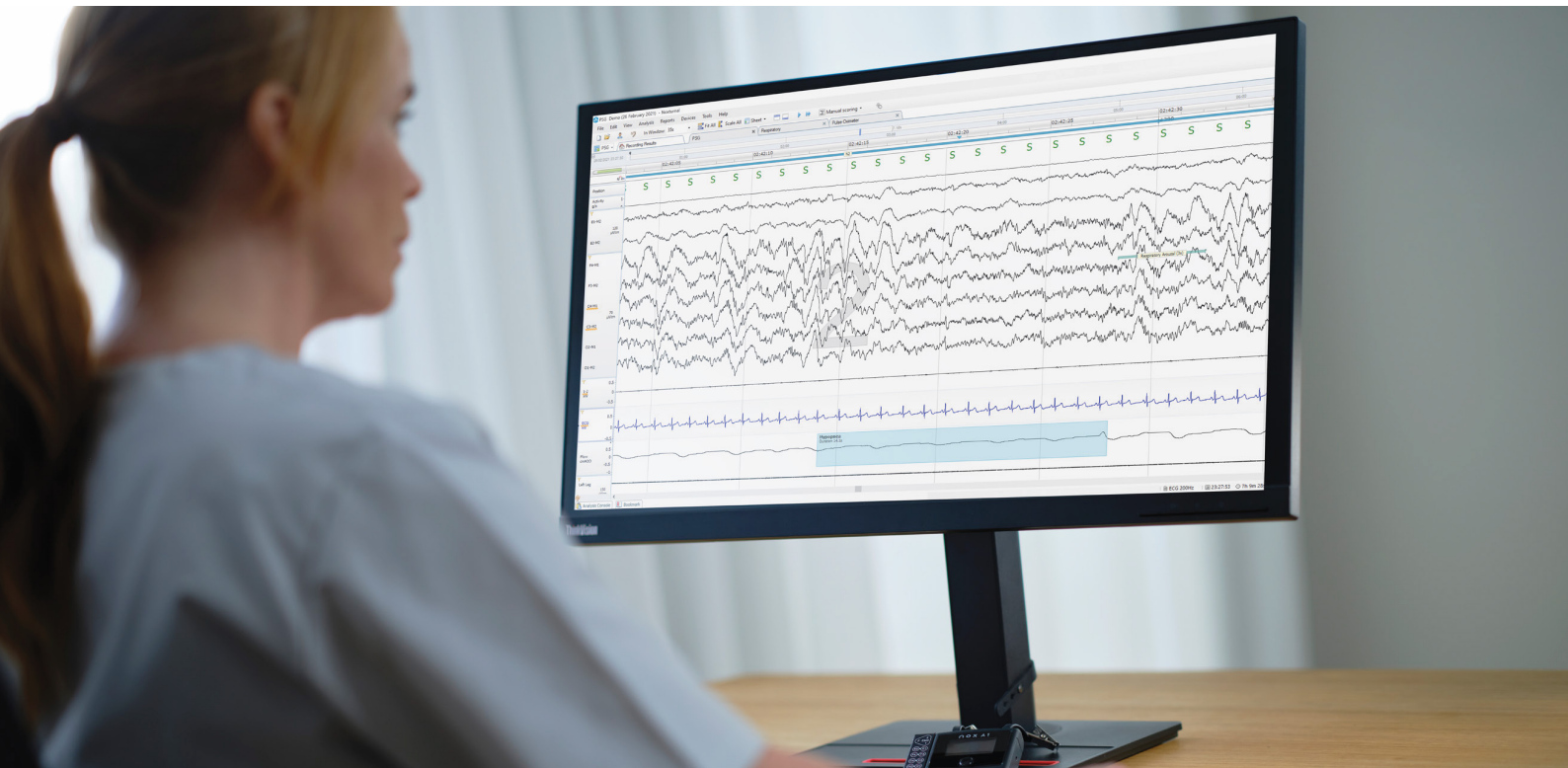
Autoscoring You Can Trust

The Noxturnal software is designed for a seamless experience for sleep technologists. It comes with autoscoring capabilities and allows for the manual scoring of the raw sleep study data.

Noxturnal includes sleep staging autoscoring capabilities, which can save time. United States-based users of Noxturnal will have the option of using sleep staging analysis that is included in the software. Respiratory flow analysis, bruxism and PLMA analysis are also available.* A confidence indicator feature is clearly displayed on the screen to tell clinicians how “confident” the automatic analysis of scoring events is during each sleep study. This feature shows the confidence of the most confident sleep stage according to the sleep staging detector on a scale of 0 to 1.

The automatic analysis results should always be reviewed by a certified technician or a physician prior to diagnosis.

*The Noxturnal automatic analyses listed in this document are available to software users based in the United States. The automatic analysis results should always be reviewed by a certified technician or a physician prior to diagnosis.



Sleep Staging Analysis

The Noxturnal software offers an automatic sleep stager to assist the manual scorer. The purpose of the sleep staging analysis is to improve the efficiency of scoring sleep stages with the intent of estimating total sleep time. The algorithm uses electroencephalography (EEG) signals, electrooculogram (EOG) signals, activity signals and submental electromyography (EMG) signals to provide pre-scoring of sleep stages, according to the AASM manual.

The automatic analysis was validated on clinical sleep recordings from an adult general population seeking medical attention with regards to their sleep disorders.

		Automatic Analysis						
		W	N1	N2	N3	REM	Unassigned	Epoch Count
Manual Staging	W	**66.7%**	3.4%	19.8%	3.6%	6.3%	0.2%	2,207
	N1	22.5%	**9.8%**	46.6%	0.7%	20.3%	0.2%	2,032
	N2	1.5%	1.6%	**87.0%**	7.2%	2.5%	0.3%	11,560
	N3	0.3%	0.1%	16.1%	**83.0%**	0.3%	0.3%	4,838
	REM	2.6%	1.0%	12.6%	0.7%	**82.5%**	0.7%	4,557

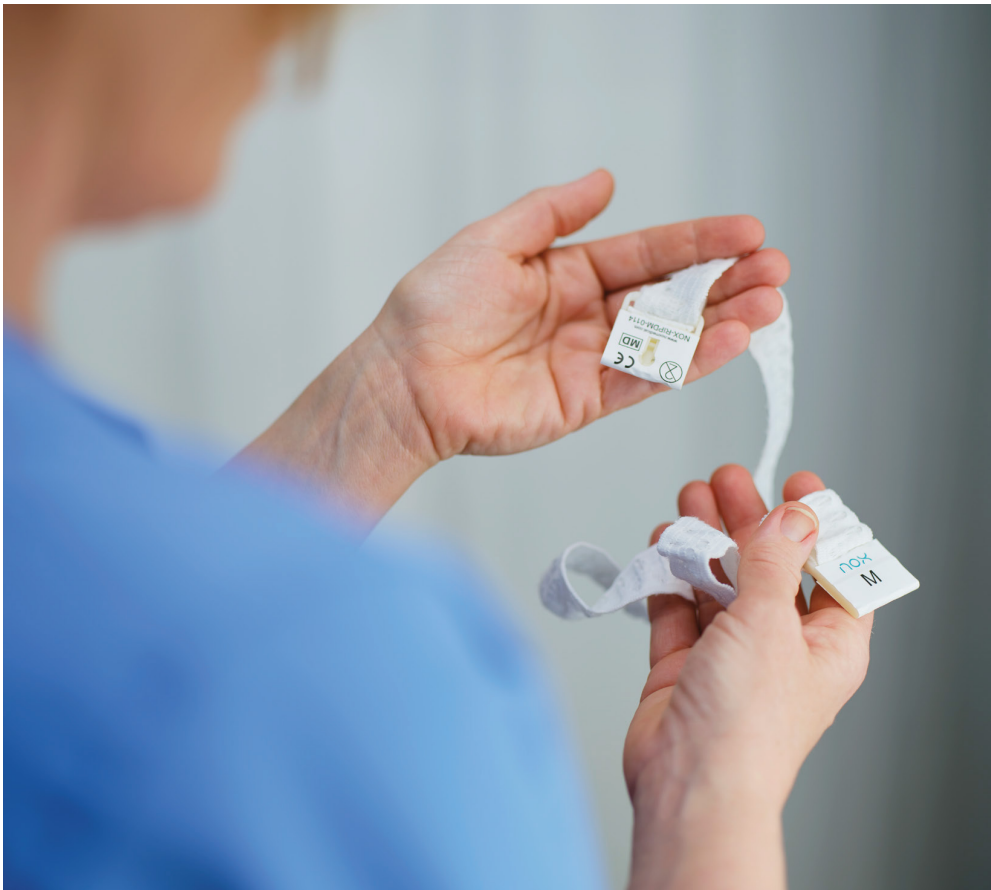
Confusion matrix comparing the classification of sleep stages with manual and automatic scoring.

Using the information provided in the confusion matrix it is possible to calculate the Sensitivity, Specificity, and Accuracy, for the binary classifications. The Sensitivity, Specificity, and Accuracy from the data in the table are:

	Sensitivity	Specificity	Accuracy
Wake	66.8%	96.7%	94.1%
N1	9.8%	98.7%	91.5%
N2	87.2%	79.9%	83.2%
N3	83.2%	95.3%	93.0%
REM	83.0%	95.8%	93.5%

Recent research publications have demonstrated that Noxturnal's respiratory analysis is accurate and reliable when compared to AHI scored manually by a human sleep technologist[1].

One study, published in the journal Sleep and Breathing, compared Noxturnal with nine human scorers from seven sleep labs across the world. The study found strong AHI scoring agreement between the automatic scoring of Noxturnal and manually scored recordings from experienced technologists[2].



[1] Xu L, et al. Validation of the Nox-T3 portable monitor for diagnosis of obstructive sleep apnea in Chinese adults. J Clin Sleep Med. 2017 May 15;13(5):675-83.

[2] Magalang UJ, Johns JN, Wood KA, et al. Home sleep apnea testing: comparison of manual and automated scoring across international sleep centers. Sleep Breath. 2019;23(1):25-31. doi:10.1007/s11325-018-1715-6

Respiratory Flow Analysis (calibrated RIP, Cannula)

The Noxturnal software also offers respiratory flow analysis that is intended to improve the efficiency of scoring apneas, hypopneas (using calibrated RIP, cannula) and desaturation events from an oximeter. Furthermore, its purpose is to improve the efficiency of classifying apneas into central apneas, mixed apneas or neither. The apnea / hypopnea index (AHI) algorithm uses as applicable the respiratory cannula flow or respiratory calibrated RIP flow signal depending on the analysis run and can utilize scored events in the EEG to score hypopneas. In the contingency tables below you can see the AHI comparison of manual vs automatic scoring using both the cannula and the RIP flow.

Cannula

AHI Manual scoring	AHI Automatic scoring: 0-5	5-15	15-30	30+
0-5	76%	7%	0%	0%
5-15	0%	9%	3%	0%
15-30	0%	1%	3%	0%
30+	0%	0%	1%	1%

k=0.78

RIP Flow

AHI Manual scoring	AHI Automatic scoring: 0-5	5-15	15-30	30+
0-5	65%	19%	0%	0%
5-15	1%	7%	2%	0%
15-30	0%	0%	4%	0%
30+	0%	0%	1%	1%

k=0.62 (95% CI 0.59 - 0.66)

Using the information provided in the contingency matrices it is possible to calculate the Sensitivity, Specificity, and Accuracy, for the binary classifications. The Sensitivity, Specificity, and Accuracy from the data in the table are:

Cannula

	Sensitivity	Specificity	Accuracy
AHI ≥ 5	100.0%	91.6%	93.1%
AHI ≥ 15	83.3%	96.8%	96.0%

RIP Flow

	Sensitivity	Specificity	Accuracy
AHI ≥ 5	94.1%	77.4%	80.2%
AHI ≥ 15	100.0%	97.9%	98.0%

Periodic Limb Movement (PLM Analysis)

The limb movement algorithm uses left leg and right leg EMG signals to identify periods where muscle tone is increased. Additionally, the activity signal is used to detect patient activity.The intraclass correlation coefficient (ICC) for the Periodic Limb Movement Index is 0.87.

Bruxism Analysis

The algorithm uses a masseter EMG signal and the activity signal. The analysis was considered to be safe if it detects at least 90% of oromandibular movements considered by a human expert to be bruxism events with 95% confidence.