

CASE STUDY

Prevent Heat Exhaustion



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Can machine learning keep first responders safe when they're most at risk?

Cloud-based systems that monitor vital signs can keep first responders and industrial workers from getting injured or even dying on the job. But what happens when people "go dark," and can't be reached by the cloud? SlateSafety wondered if their award-winning BAND V2 could deliver real-time alerts even without connectivity. In just 10 days, working with the vast amount of biometric data generated from the field, SlateSafety and the Edge Impulse team were able to zero in on key parameters and create an accurate, compact algorithm for predicting heat exhaustion. The new algorithm, which runs directly on existing hardware, can give the wearer real-time feedback on the risk of heat exhaustion, and enhances existing products by making safety at the edge a working reality.

Results

- An accurate and efficient ML algorithm, ready to run on SlateSafety's existing Nordic-based device
- A 10-day development timeline, enabled by Edge Impulse's Solutions Support Team and Edge ML platform
- Real-time situational awareness, to avoid overexertion injuries and fatalities, even in areas without connectivity



Founded in 2016 as FireHUD, Atlanta-based SlateSafety is a technology company that provides easy-to-use, real-time group physiological monitoring to first responders and industrial workers.

The SlateSafety BAND V2 withstands the toughest environments to provide always-aware safety monitoring.



SlateSafety BAND V2

[View Product](#)

Core Body
Temperature



Heart
Rate



Current
Exertion

Specialized biometric monitoring

SlateSafety is a niche technology supplier, meaning they do one thing very, very well. So well, in fact, that their flagship product, the BAND V2, was named a best invention of 2021 by Time magazine.

SlateSafety BAND V2 is a specialized wearable that looks for signs of stress when people are doing dangerous work, in extreme environments, and at risk of overexertion. Worn on the arm, under personal protective equipment (PPE), the SlateSafety BAND was originally designed for firefighters, since prolonged exposure to high temperatures, while wearing heavy protective gear, and

having to carry or lift heavy objects, can easily lead to heat stress, overexertion, and other life-threatening conditions.

*Time magazine
named SlateSafety's
BAND one of the best
inventions of 2021*

The US Fire Administration, the lead federal agency for fire-data collection, reports that sudden cardiac death (a condition that can be brought on by overexertion), has been the number-one cause of on-duty firefighter fatalities in the US since the 1990s and, in almost every year, has accounted for the single largest share of firefighter deaths in the year. Military personnel and industrial workers are often required to wear heavy PPE, too, and can be

subject to the same risks of overexertion.

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We're aggregating sensor data to produce more useful results. With the Edge Impulse platform, we were able to find patterns in our data quickly, and develop a specialized algorithm tailored to our needs. As a startup we're always looking for quicker ways to free up time and tackle other problems that walk through the door.

Joe Boettcher, Chief Development Officer, SlateSafety

As a result, the BAND V2 is used by various industrial sites, the US Army, and the US Air Force, as well as dozens of fire departments.



How it works

Looking under the hood, the BAND V2 is a heat-tolerant, auto-recording device that provides valuable biometric data without taxing the wearer. As a lightweight arm band, it doesn't interfere with mobility and, because it's always on, with no buttons to press, there's no chance of the wearer forgetting to start the monitoring function once they slip it on.

The device is equipped with a sensor that tracks heart rate. Based on the sensor readings, SlateSafety algorithms extrapolate other biometrics, such as core body temperature, calories burned per minute, steps per minute, and exertion.

The algorithm then identifies trends and, if there's cause for concern, sends an alert to a designated person, such as the fire chief or troop commander, so a decision can be made on how to proceed.

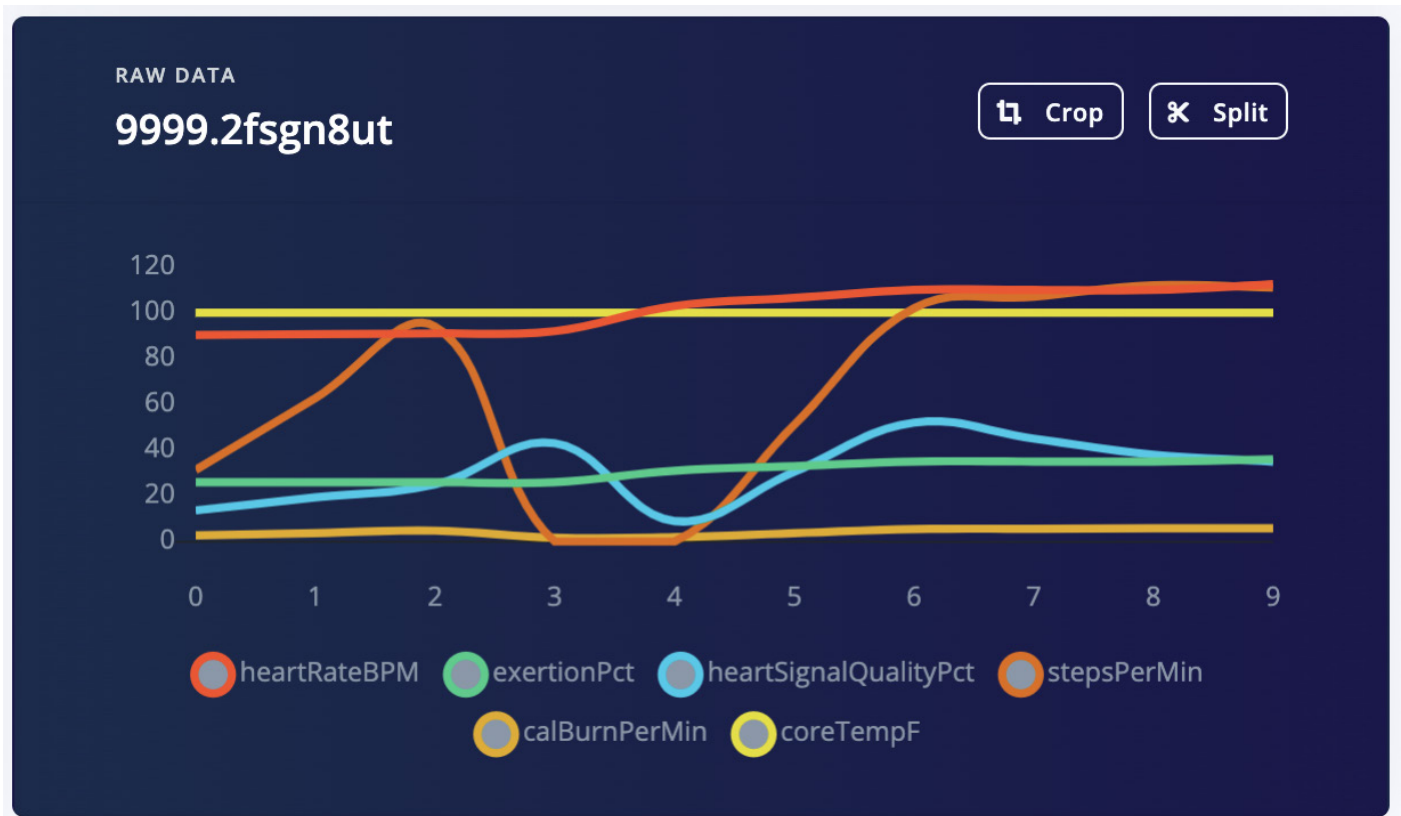
Using heart rate and motion biometrics, SlateSafety can predict future body temperature and prevent heat exhaustion for personnel in the field

Each BAND V2 sends data to a web interface for real-time alerting.

Moving to the edge

The SlateSafety BAND was one of the first safety devices to send data to the cloud for processing and, as mentioned above, has been recognized for its innovation and ability to keep connected workers safe.

But people fighting fires aren't always within reach of the cloud. Depending on the situation, they can find themselves in remote areas, underground, or in other places where cloud connectivity is either too unreliable for effective monitoring or simply unavailable. To protect workers wherever they're needed, SlateSafety wondered if they could move the processing to the BAND V2 itself, for always-aware monitoring without connectivity.





Making the sensors smarter

Beyond adding more awareness to the device itself, SlateSafety was also interested in adding predictive capabilities to their algorithms, using machine learning. It was helpful to know current core temperature readings, but it was even more useful to know what those readings were likely to become in the next five to ten minutes, so preventive measures, such as pulling someone out of the field,

could be taken before the worst happened.

SlateSafety's new ML algorithm, which took only 10 days to develop, runs on their existing Nordic-based device and is available as an over-the-air update

Edge Impulse made it possible

Edge Impulse studio, designed to help developers and

enterprises get higher-level insights from their sensor data, enabled SlateSafety to develop more advanced on-device monitoring and prevention of heat exhaustion.

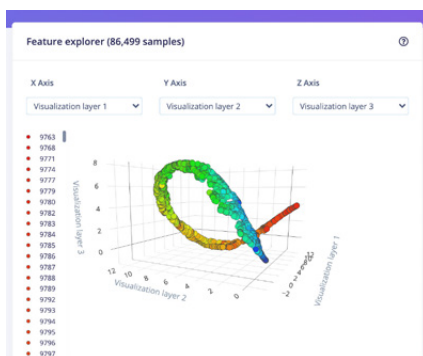
SlateSafety's developers were able to quickly and easily build ML and deep-learning models utilizing Edge Impulse's platform.

Perhaps the most impressive part of the project is that they were able to do all this in just 10 days, start to finish.



Using data they'd already collected

Machine learning begins with data, since the better the data you use to train the algorithm, the better your results. The Edge Impulse platform helped SlateSafety sift through their data, and the EON.



Tuner helped them identify the machine learning pipeline that

best suited their use case and dataset. Thanks to Edge Impulse, SlateSafety was able to rapidly simplify the problem by narrowing the feature set for training to just three parameters: heart rate, core body temperature, and core exertion.

A dramatically faster development timeline

Working with the Edge Impulse platform and the Edge Impulse's Solutions Support Team, SlateSafety was able to save untold hours of development time. SlateSafety prepared and analyzed the vast amount of data they had already collected and using the EON Tuner rapidly

found the optimal solution in just 10 days. To perform end-to-end optimizations, from the digital-signal processing (DSP) algorithm to the machine-learning model, while keeping the latency and memory requirements of their target device in mind, the team used the EON Tuner. SlateSafety was able to quickly identify the ideal trade-off between the different pre-processing and neural-network architectures and to achieve optimal performance, on their device. This kind of optimization is usually only done by data scientists, using complex model-training systems and codebases. With the EON Tuner everyone has now access to the same level of expertise.

Using the hardware they already had

Having trained their project on the three features, the next challenge was to create source code that could run on SlateSafety BAND's existing microcontroller. Memory is one of the scarcest resources on Using the EON Compiler, SlateSafety was able to create an algorithm that was so compact it could run in the existing design without changes. There was no need to upgrade the processor or add memory, so SlateSafety could introduce the new, predictive capabilities without having to go through a hardware redesign. The Edge Impulse development environment also includes a custom deployment block, which automates new model

generation and makes it possible to pipe the new algorithm into SlateSafety's own CI/CD flow, for quick testing and deployment.

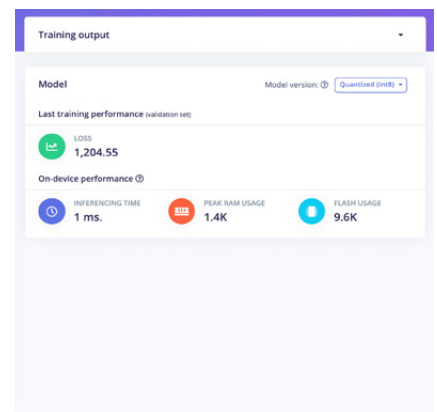
EON Compiler for a tiny model

Typical ML runtimes use a generic interpreter to load the model at runtime. This tends to be a more memory-intensive approach, which can be difficult to deploy in embedded systems.

The EON Compiler produces a neural network that uses, on average, 25 to 55% less RAM, and up to 35% less flash, while retaining the same inference speed (latency) and accuracy, when compared to an uncompiled model using TensorFlow Lite for Microcontrollers.

New capabilities for existing devices

Another benefit of developing such compact algorithms is that SlateSafety can send new functionality to BANDS V2 already deployed in the field, as over-the-air (OTA) updates. This increases the lifespan and utility of existing devices, making the initial investment in technology that much more valuable. The ability to send OTA updates for new algorithms means SlateSafety can introduce new capabilities as soon as they're ready, without sending personnel into the field or issuing end-of-life announcements for their devices.



Ongoing evolution

What's more, since SlateSafety already has such an extensive amount of collected data, and can quickly identify and extract new features for ML training, they can easily explore new, prevention-first approaches that will provide even more advanced protection and help save further lives.





Learn more:

Edge Impulse for data-driven engineering

Edge Impulse is the fastest growing development platform for edge machine learning, used by thousands of enterprises across 55,000+ ML projects worldwide. We are on a mission to enable the ultimate development experience for machine learning on edge devices for sensors, audio, and computer vision, at scale. From getting started in under five minutes to MLOps in production, we enable the development of highly optimized ML models deployable to a wide range of hardware from MCUs to GPUs.

To learn more visit www.edgeimpulse.com

About SlateSafety

Atlanta-based SlateSafety is a technology company that provides easy-to-use, real-time group physiological monitoring to first responders, the military, and industrial workers. SlateSafety aims to make jobs safer with rugged, reliable, and revolutionary connected safety technology. SlateSafety has received funding from the National Science Foundation, the National Institute of Standards and Technology, as well as the US Air Force and Army to accelerate the development of its IoT platform.

To learn more visit www.slatesafety.com

