

WHITE PAPER

Accelerating Growth & Revenue in Cold Chain with Edge Machine Learning



According to a report by the research firm Brainy Insights, the global cold chain logistics market is growing rapidly. In 2020, this market was estimated to be worth \$188 billion, but in just 8 years, it is projected to grow to \$842 billion, a CAGR of 22.2%. (1)

Without a doubt, cold chain is becoming an integral part of our logistics economy. Given the recent supply chain issues worldwide, it is even more critical that manufacturers of goods such as perishables, vaccines and food products are given deeper insights into the delivery logistics of their products. Every batch of lost product due to issues in the supply chain, can be costly to the tune of millions, or even billions of dollars. (2)

Consumers are also demanding more transparency into how the medications and foods they consume have been handled. In a survey of 3500 patients and pharmaceutical industry leaders which was conducted by Zebra Technologies, a leader in supply chain marking and tracking sensors, “nine out of ten say it is somewhat or very important they can verify a medication is not counterfeit [or] tampered with and confirm temperature sensitive medications have stayed within the prescribed range.” (3)

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These evolving patient demands will certainly be a wake-up call for pharmaceutical industry leaders who, for years, have been primarily focused on meeting regulatory standards... Manufacturers, government agencies, pharmacies, and healthcare providers must work together to win consumers’ trust in the supply chain.

–John Wirthlin

Industry principal for manufacturing, transportation, and logistics at Zebra Technologies

It is becoming increasingly critical that companies can track cold chain assets as they move from point A to point B, to guarantee to customers that they are not receiving a spoiled medication, vaccine or food product.

Machine Learning for Cold Chain

Machine learning is a broad term, but as it relates to cold chain, we will focus on machine learning at the edge. Machine learning on the edge refers to intelligent algorithms that can be deployed directly to sensor devices, rather than to the cloud or a cluster of servers. For cold chain, this could mean deploying algorithms directly to loggers or sensors monitoring assets directly, or perhaps deploying to a gateway or mobile device that aggregates the data from several cold chain tracking sensors.

The benefits of deploying machine learning algorithms directly to the edge exist from both a cost and technical perspective. **BLERP**, or **B**andwidth, **L**atency, **E**conomics, **R**eliability, **P**ower, is an acronym that encompasses the main benefits of edge machine learning. (4) We will examine these below as they relate to the cold chain industry.

Bandwidth

Most low power wireless communication protocols such as Long Range Wide Area Network (LoRaWAN) or Narrow Band Internet of Things (NB-IOT) have limited bandwidth, meaning they cannot send large amounts of data wirelessly. However, by running machine learning locally, raw data no longer has to be streamed, instead already processed results from the algorithms running on the sensor or gateway can be streamed over a low-bandwidth wireless protocol.

Latency

Sending data to the cloud when an asset is in transit, may not always be feasible. With edge machine learning, because algorithms run directly on the device, real-time results can be obtained, and wireless transmission can occur only if an important event is detected through the algorithms on-device.

Economics

It is not cost effective to send large amounts of raw sensor data to the cloud. This is expensive from a cloud storage and compute perspective. Now, data can be processed using the edge device or gateway's compute, and can be selectively sent out when it makes sense (i.e. the asset temperature is going out of range, so send a notification or alert).

Reliability

Given that an asset may be moving through remote environments or areas with low connectivity such as an airplane or sea carrier, reliable wireless connection cannot be guaranteed. Bringing some intelligence to the edge, ensures that algorithms can keep running even without wireless connectivity to the cloud.

Privacy

It may be important to keep data being collected on high-value assets secure. Because algorithms are processed on-device, raw data does not have to be frequently transmitted, which creates a vulnerability for data to be intercepted by bad actors. Furthermore, machine learning can be used to "encrypt" the data in a sense, by having the algorithm output classes that are not understandable except to those who the data is meant for.

For the cold chain industry, these all serve as important benefits of edge machine learning for asset tracking sensor manufacturers such as Sensitech, Xirgo and CalAmp. Long battery life, reliability, responsiveness and cost are all differentiators for end customers when selecting a certain vendor or lineup of cold chain monitoring solutions.

Intelligent Cold Chain Algorithms

Edge solutions providers are helping make developing intelligent cold chain algorithms possible. Platforms like Edge Impulse are democratizing the skills to build edge machine learning algorithms, through a low-to-no code machine learning ops (MLOps) platform. The company's focus is helping customers put in production effective cold chain monitoring solutions with the help of edge machine learning.

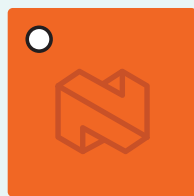
Cold chain sensor solutions providers work with the Edge Impulse team to build edge ML solutions for gaining insight into their products using environmental and vibration sensors.

One recently completed project in the Edge Impulse platform uses a Nordic Semiconductor Thingy 91 hardware board to collect and process accelerometer,

humidity and temperature data for understanding if a package has been exposed to sun, experienced being dropped or shaken, or has been overheated. This ML-based classification model was developed by collecting data representative of the various states, labeling it and using it to train an algorithm to differentiate between them. Should one of these events be detected, an MQTT message is sent via cellular network from the antenna on the Nordic board.

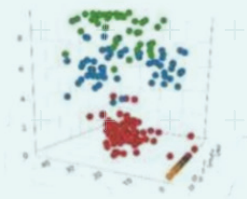
The insights provided through an example like this can enable actions to be taken if a shipment is at risk of being spoiled or damaged due to its handling. With real-time notifications, drivers or operators of the vehicle containing the shipment can be warned of shipment risk and can take appropriate action. The cost savings both a product manufacturer, as well as logistics provider, could recognize from proactively addressing supply chain issues such as these are potentially massive.

Cold Chain Monitoring using Edge Impulse



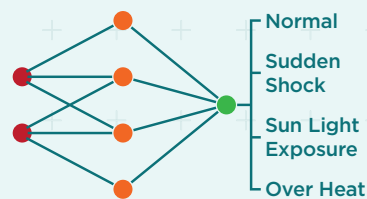
Nordic Thingy: 91

Accelerometer
Humidity
Temperature
Infrared



Data Acquisition

Flatten
Spectral Features
Raw



Neural Network Classification

Real Time
Tracking



The Future of Cold Chain Technology

The future of cold chain technology will be multi-faceted, but edge machine learning will have a part to play. A large portion of this expansion of edge processing will happen in low-power, tiny devices. In 2022 alone, it is estimated that 1.2 billion devices with tiny machine learning (ultra-low power devices like cold chain sensors) will be shipped. (6)

Machine learning is already prevalent in certain industries such as smart buildings and autonomous vehicles. However, not all machine learning algorithms will be suitable to run solely on the cloud, due to the constraints previously mentioned. This is where technology vendors like cold chain solutions providers must be proactive in developing algorithms that will run natively on their products. It will be a competitive advantage to have historical sensor data that can be aggregated, labeled, cleaned and used to rapidly develop ML algorithms that run directly on cold chain sensor devices or gateways.

If you're interested in learning more about cold chain industry trends, please check out the links below.

You can also chat with the Edge Impulse team about how your company can get started building edge ML based cold chain solutions by filling out the form [here](#).

Sources

- (1) <https://www.prnewswire.com/news-releases/cold-chain-logistics-market-to-grow-at-a-cagr-of-22-18--a-surge-in-consumer-demand-for-perishable-foods-to-boost-growth--the-brainy-insights-301485636.html>
- (2) <https://pharma-mon.com/drug-storage-monitoring/the-cost-of-a-broken-cold-chain-in-the-pharmaceutical-industry/>
- (3) <https://www.dvvelocity.com/articles/53025-study-highlights-pharmaceutical-supply-chain-problems>
- (4) <https://www.eetimes.com/ai-and-vision-at-the-edge/#>
- (5) <https://www.edgeimpulse.com/blog/a-cool-package-monitor>
- (6) <https://www.abiresearch.com/press/2022-will-be-the-year-tinyml-catches-on-with-12-billion-device-shipments/>



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