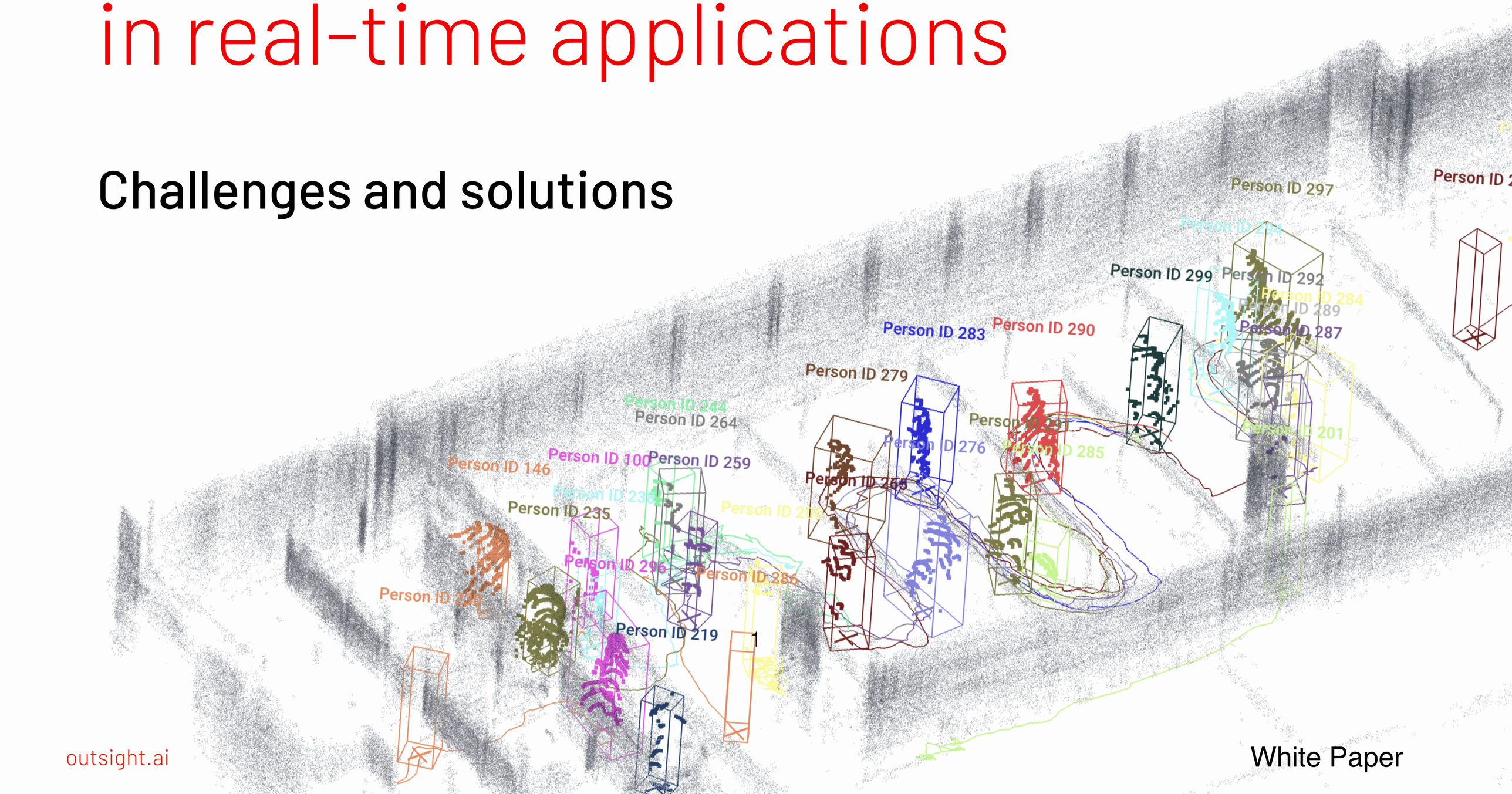
outsight

Using LiDAR
in real-time applications

Challenges and solutions



About Us

Outsight develops real-time 3D LiDAR perception solutions.

Our mission is to make LiDAR-based Spatial Intelligence become plug-and-play so it can be used by application developers and integrators in any market.

Using any LiDAR with our Software processing capabilities allows Smart Machines and Smart Cities to achieve an unprecedented level of situational awareness.

We believe that accelerating the adoption of LiDAR technology with easy-to-use and scalable software will highly contribute to creating transformative solutions that will make a smarter and safer world.

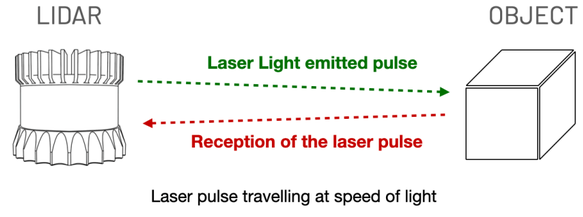
To learn more: https://www.outsight.ai/

What is LiDAR?

NASA initially developed LiDAR in the 1970s for use in space. It uses laser beams to create 3D vision for a computer to perceive its surroundings.

Light Detection and Ranging, also known as LiDAR, is a technology for remote sensing that is used to measure distances in an environment.

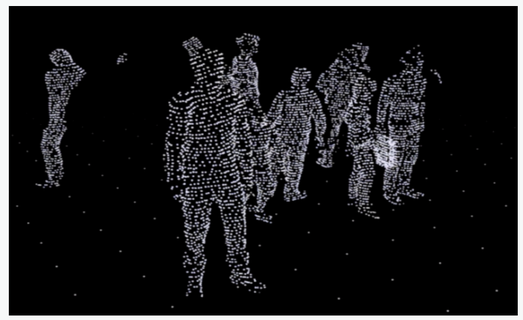
This is accomplished by illuminating the environment in question with light that is invisible to the human eye and timing how long it takes for the light to reflect back.



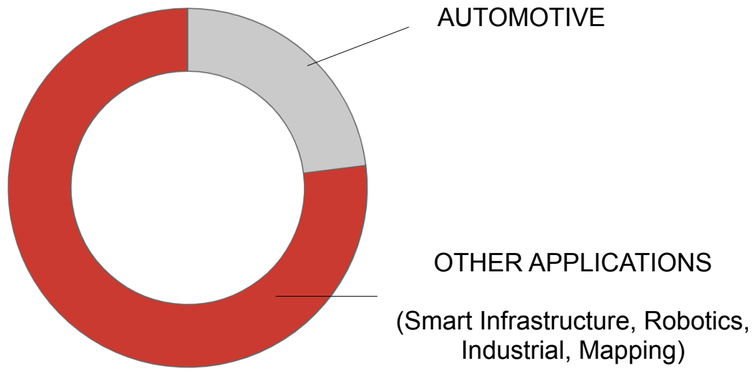
Repeating this process millions of times per second gives computers an accurate portrayal of the environment that is being scanned, allowing them to "see" the world in three dimensions.

Unlike existing 2D-based perception technologies such as cameras, the 3D data from LiDAR produces highly detailed, accurate spatial measurements and works in a range of environments and contexts, such as during the night and under direct sunlight.

When deployed at scale, LiDAR also offers an important nontechnical advantage: no personally identifiable information is ever captured.



If LiDAR is such an attractive technology, why aren't we seeing it used more often?



Non-automotive verticals represent a bigger opportunity for LiDAR*, and many sensor models with the right price-performance ratio are currently available

* Sources: LiDAR for Automotive and Industrial Applications, Yole Development 2020, Outsight Research

From smart cities to autonomous machines, companies in both the public and private sectors are increasingly looking to leverage the benefits of 3D perception.

Application developers are turning to 3D LiDAR either to replace legacy sensing technology or to create solutions that were once unachievable.

Unlike existing 2D-based perception technologies, LiDAR produces highly detailed, accurate spatial measurements and works in a range of environments and contexts such as during the night and under direct sunlight.

LiDAR also offers an important nontechnical advantage when deployed at scale: no personally identifiable information is ever captured.

Beyond automotive

The automotive sector has been a highly publicized early adopter of the technology.

While the technology is still too expensive to be affordably deployed in an average consumer car, the intense competition among more than 80 new LiDAR sensor manufacturers has already achieved a more attractive performance-to-cost ratio in almost any other less price-sensitive application in many vertical markets such as smart cities, security, mobile robotics and industrial applications.

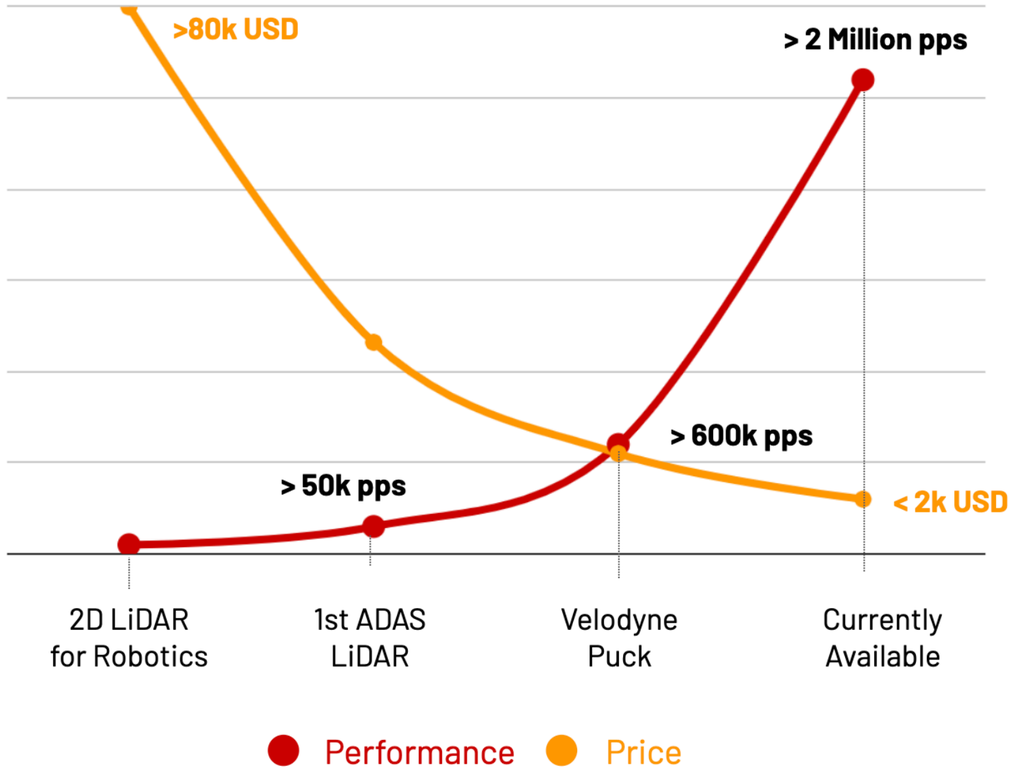
Companies are always looking for ways to improve their operations and differentiate themselves, so what's holding LiDAR back? Contrary to what the majority of observers who are primarily focused on the automotive industry think, it's not cost or performance that's inhibiting a broader adoption of LIDAR.

Instead, it's the complexity associated with this new technology.

Price and performance are no longer barriers to widespread adoption

Hardware is maturing and becoming more affordable.

There are many sensor models on the market right now with the right price-performance ratio, because, unlike automotive, prices in the tens of dollars are not an absolute requirement for deployment in most applications.



Similarly, performance is rapidly improving, with millions of points per second becoming the norm rather than the exception.

This allows for use cases that were previously impossible with low-resolution models.

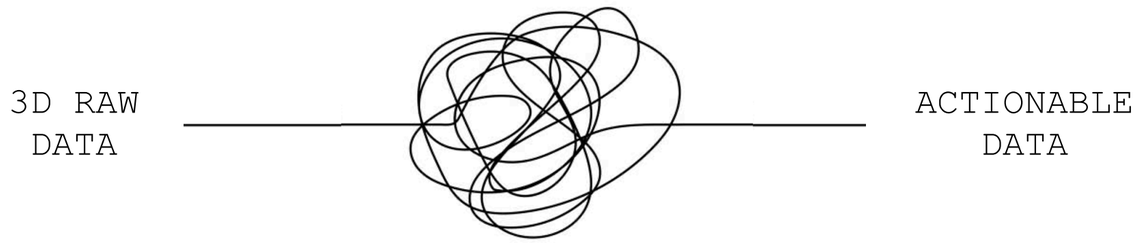
LiDAR opens up many opportunities beyond self-driving cars, but adoption is limited by its complexity

Much has been said about the potential of LiDAR and the innovative solutions it enables in the automotive market.

There is, however, a lack of content about the LiDAR processing complexity in other contexts and, most importantly, how to solve it.

This is especially true when the task at hand requires real-time output, a very different challenge compared to situations where relatively long post-processing times are acceptable (e.g., mapping).

This white paper explores the main challenges that technology integrators and solution providers must face regardless of the target application (mobile robotics, industrial, smart infrastructure) and the pros and cons of the different approaches to solve them.



> Tackling the complexity of processing raw data from LiDAR in real-time is **inefficient**, **long**, **risky**, and **expensive** for most applications.

The challenges of using LiDAR

Integrating LiDAR into an application creates several challenges, but most of them can be navigated with intensive expert support. It is bearable during the initial phase of an emerging market but it prevents the rapid development of high-impact mainstream applications.

These challenges include the following:

Assessing which LiDAR sensor best suits your solution

The array of choices can be a source of frustration for developers.

In addition, the information provided by manufacturers, including points per second, field of view, frame rate, and more, do not easily translates into actionable metrics for the end application.

A solution developer can consequently come to the wrong conclusions about the best fit for their project.

> For example, an expensive sensor with an unnecessarily high resolution can be chosen instead of a cheaper, lower-resolution alternative from the same manufacturer that would have worked just as well.

Evaluating your short list of LiDAR sensors

Since LiDAR is a young industry, it lacks established standards.

Each LiDAR sensor uses a unique data format and network interface that requires a specific driver to decode the data as well as specific SDKs or frameworks.

> In practice, that leads to limiting the number of manufacturers who are evaluated, likely missing better and/or cheaper alternatives.

The challenges of using LiDAR

Using the selected LiDAR sensors

Point cloud data is complex to interpret in real-time without expert help.

The raw point cloud data is sparse and abstract, requiring significant resources and expertise to turn it into information that can power useful applications.

> The resulting applications can thus miss LiDAR's true potential, or developers can come to the wrong conclusion that LiDAR is not yet at the necessary level of performance.

Integrating the sensor into an application

Each manufacturer's sensor uses different data formats, voltage levels, connectors, and network transport protocols.

The ever-increasing resolution of newer LiDARs add to the challenge, creating a massive amount of 3D data that needs to be transmitted and processed.

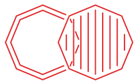
As a direct consequence, application developers must use expensive, high-end computing platforms, specific wiring, and wide bandwidth connections— or give up using LiDAR in their applications when this is not acceptable or possible.

Maintaining and improving the system

Most LiDAR sensors aren't designed to handle over-the-air updates and improvements, nor are they designed to be backwards compatible with models from different generations— even if they're from the same manufacturer.

While this was acceptable in the early phase of prototyped LiDAR technology, it is incompatible with large-scale professional deployments.

The challenges of using LiDAR



Combining multiple LiDARs and other sensors

When an application can't be performed by a single sensor, integrators and developers must merge data that originates from several of them.

In some cases, LiDAR data must also be combined with camera, radar, and other sensors.

> Without adding value to the end product, this entails **tackling calibration, synchronization, and networking complexity that delays the creation of the actual application.**

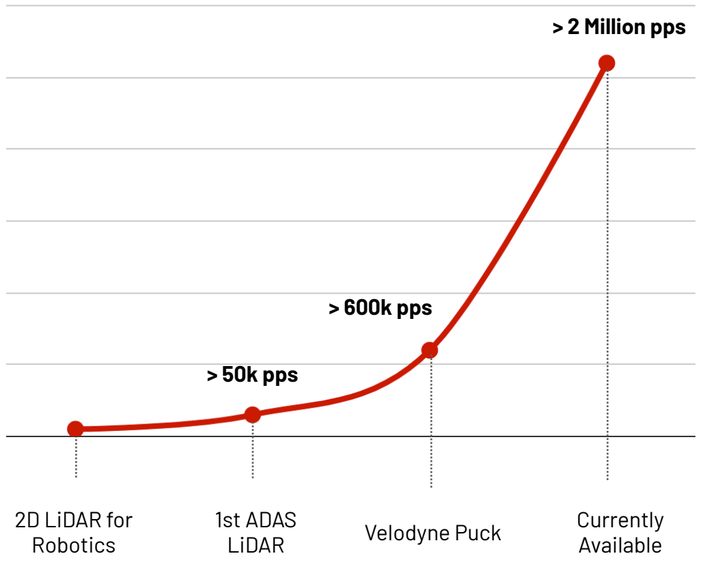
That becomes even more complicated when the best solution to solve the problem at hand is to combine sensors from different manufacturers.

Often, that is the best choice as each LiDAR provider uses specific underlying technology approaches that have their own strengths and weaknesses (e.g. wavelength, scanning vs. flash, fixed pattern vs. dynamic…)

> **Example**
>
> Combining a 360⁰ field of view LiDAR with sensors that have a narrow field of view can offer the best of both worlds:
>
> - in situations where you want to monitor a wide area such as the entry of an airport terminal (360⁰ and ceiling-mounted sensors are better).
>
> - while monitoring certain aisles at the same premises (task best suited to narrow FoV LiDAR that will concentrate the laser energy and provide higher resolutions)

Why is LiDAR data so hard to use?

Most of the latest advancements in Computer Vision, including Machine Learning, are related to 2D image data, which cannot be directly applied to 3D LiDAR



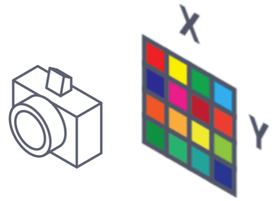
The **Points per Second** (pps) metric defines how many Laser pulses are sent by the sensor. It is a convenient way to measure the progress of LiDAR technology as it directly translates to resolution and doesn't depend on other factors such as FoV and frame rate.

The amount of 3D data to be processed is growing very quickly.

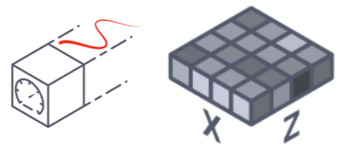
3D data is complex to interpret and use because it is sparse and fundamentally different from the 2D RGB images that Computer Vision specialists are used to working with.

That becomes even harder when considering a moving platform such as a mobile robot and the increasing massive amount of data that newer sensors provide.

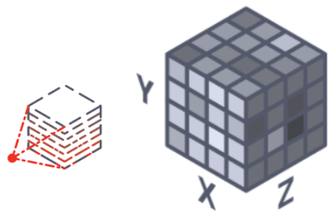
> Modeling 3D data as RGB-D has been wrongfully considered a quick-win approach, with "D" standing for the depth dimension that could be considered as an additional color channel by traditional image processing pipelines.



High-definition color data is a good fit for tasks such as object classification.



Radar data is low resolution but provides unique spatial insight such as axial velocity.



The 3D nature of LiDAR data makes it different from other sensors. It requires specific processing techniques.

Although this corner-cutting method allows you to recycle 2D-based techniques and get quick results, it's not suited for anything but the simplest use cases.

Raw data is not actionable

3D LiDAR for real-time operation was designed in the context of developing new technologies with long term objectives such as autonomous vehicles

Making real-time LiDAR usable in mature, business-driven applications requires delivering actionable insight

In order to differentiate themselves, LiDAR manufacturers mainly provide technical specifications like angular resolution, range at different reflectivity percentages, the field of view, frame rates, and many more.

Early adopters of LiDAR, like the first autonomous driving engineers, loved this level of Raw data information.

However, in most other applications, LiDAR technology is irrelevant *per se*.

> The focus of the top professionals in Smart Infrastructure, Robotics and Industrial applications is **on the problem it helps solve.** Actionable data is what is required in practical real-world use cases.

RAW Data Langage	Actionable Insight for Real-World Applications
Raw 3D point-cloud	Where are the objects and obstacles around me? Are they moving? Where is the ground? What's my position?
Angular resolution, Number of layers	What's the smallest object I can detect at a certain distance? Where is this object ?
Millions of 3D points per second	Only relevant points and objects delivered in narrow-band with low-power processing.
Field of View	Can I use this for localization purposes? Only for perception or both?
Wavelength, Peak power	How well does it work when it rains?
Framerate	What's the maximum moving speed that delivers meaningful data?

The challenges of using LiDAR

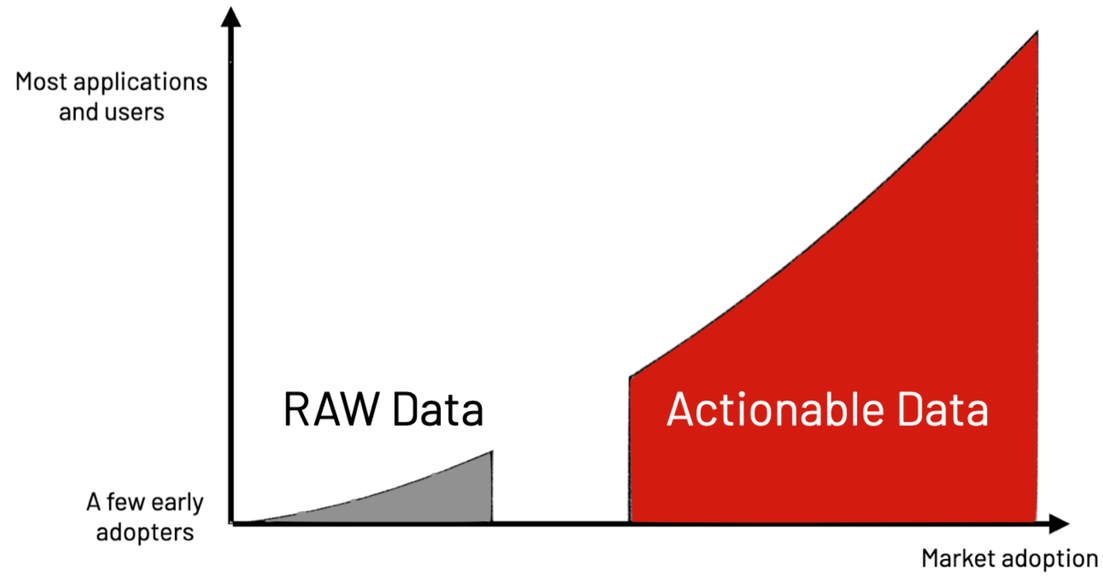
CONCLUSION

These issues make integrating LiDAR into new applications a frustrating experience for even the most seasoned teams.

That is particularly true in the majority of applications where LiDAR data processing needs to be done in real-time, in contrast to some traditional use cases such as mapping that can live with the delay associated with post-processing approaches.

Solutions can also become prohibitively expensive or quickly obsolete if they rely on the wrong LiDAR sensor, they can take much longer than expected to deploy, or just won't work as they should.

> The complexity, uncertainties, and time needed to develop LiDAR-based solutions inhibit many organizations from bringing their 3D-enabled products to market, squandering potentially crucial competitive advantages and losing the opportunity to leverage the unique benefits of this awesome technology.



How to navigate the challenges of LiDAR integration

The DIY approach

Hiring a team of experts to build an in-house full stack software to integrate LiDAR

2 to 5 years

$ 12 to 20 million

Estimated* cost and development time of an application-specific full stack LiDAR solution, depending on the level of features and required performance.

Can be less for non-professional solutions and up to three times more in cases of a multi-application solution and/or safety-critical systems.

** Source: Independent expert audit on behalf of France's Banque Publique d'Investissement (BPI France)*

The Pros

- Gives you, the application developer, almost **complete control**.
- Provides the **freedom to build custom solutions** that fit your application. This would be expensive if it were built by an engineering services company.
- Allows you to **create intellectual property (IP)** for your company, and the developed solutions can become a differentiating factor for your company.

The Cons

- It can be **hard to find and retain talent**, which translates to long delays to build the solution.
- It can be **expensive to build and maintain an internal team** since LiDAR experts are rare and increasingly sought after.
- There's **no way to guarantee the successful development** of a LiDAR solution. The technology is highly complex and constantly evolving with a risk of never reaching completion.
- **It takes a great deal of time** to go from a demonstrator to a product after identifying and eliminating bugs, performance issues and inefficiencies. You must think long-term.
- An internally designed solution may not measure up to currently available solutions by the time it is released, rendering it **non-competitive**.
- The choice to build a solution internally can **distract the team** from focusing on value-added tasks that satisfy customer needs and create application-specific differentiators.
- It can be **difficult or impossible to leverage** what other industries with similar needs have learned over the years or are currently developing.

How to navigate the challenges of LiDAR integration

The Engineering Services way

Partnering with an Engineering Services provider can be a good alternative to an in-house development

The Pros

- **Can be less expensive** as long as the objective is close to what the service provider has already built.
- You gain access to a team of experts who can **leverage their experience from other industries**.
- It is a time-based commitment that transitions to **results-based pricing**.
- **You may be the owner of the solution's IP in some cases**.
- There is a **quicker time to market and more focus** of your in-house team on added-value projects.

The Cons

- Given the time and budget pressure, the partner may have **a tendency to cut corners**. This option generally comes with a cost to long-term success and maintainability.
- Other more important projects may demand more of their attention, and **the best talent can be allocated out of your project**.
- You may need to **surrender valuable product or IP rights**. While you'll be allowed to use the finished system, it's not likely that you'll hold IP ownership rights for your application.
- **Very few companies can reliably provide the necessary level of expertise**. The companies that can assemble and maintain a competent team are very limited.
- Even when outsourced, this option **requires significant time and resources** to manage the provider, taking the attention of your engineering team away from other projects or clients.
- If the solution is over-fitted for a certain hardware, **its long-term durability can be compromised.** The LiDAR market is highly dynamic and the position of today's LiDAR hardware market leaders is precarious, given the industry is still in its infancy.

Using a 3D Pre-Processor

LiDAR pre-Processing software is a new participant in the 3D real-time value chain.

It provides an easy way to use LiDAR in any application.

The **Augmented LiDAR Box©** is an Edge Processing device that embeds Outsight's real-time software.

More information at www.outsight.ai

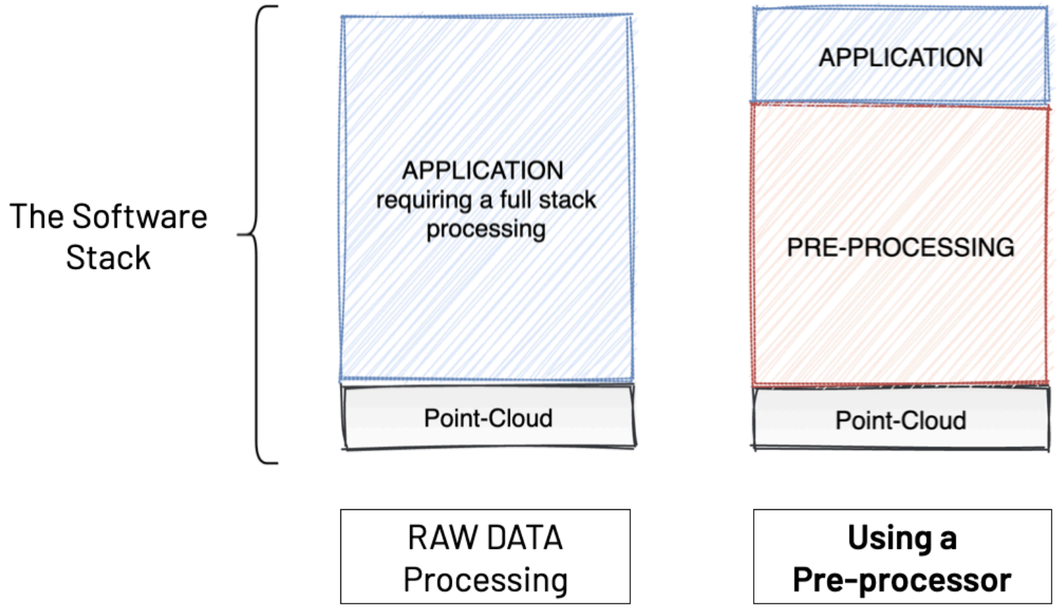
What is a 3D LiDAR pre-processor?

As mentioned previously, making use of the raw data provided by LiDAR sensors is challenging. **Pre-processing software eliminates that problem.**

Running in real-time, LiDAR pre-processing software takes raw 3D data as an input and instantly converts it to accessible, actionable insight. Simply put, it helps LiDAR sensors localize, track, and classify objects, making it easy for application developers to build their solutions.

The **Augmented LiDAR Box©** has set the global standard for LiDAR pre-processing software, delivered on a convenient plug & play Edge device.

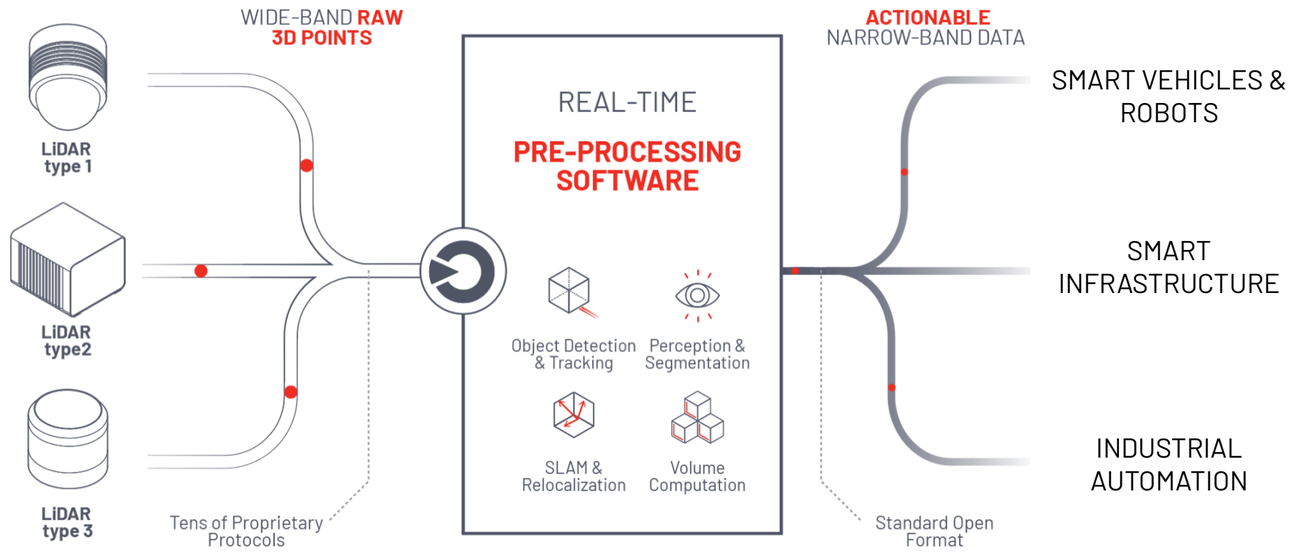
> As its names indicates, a pre-processor doesn't replace the application-specific software but facilitates and accelerates its development.



Pre-Processing Overview

In a nutshell, a 3D software pre-processor plays four different roles at once:

- abstracting the hardware complexity,
- standardising the output,
- performing key features & algorithms,
- and highly decreasing the bandwidth and processing power requirements of the application host.



The four main functions that a Pre Processor performs simultaneously are:

1. **Abstracting the Hardware complexity (input):** this means that the application developer won't have to worry about creating a unique driver for each Sensor, as well as adding features that allow data from different manufacturers to be fused (combined).

2. **Standardising and simplifying the output regardless of the input:** for a LiDAR pre-processor to accomplish its purpose, it must provide an open data format.

3. **Make the data processing heavy lifting,** that is, perform the key features that are commonly required in most applications: SLAM, Object tracking and classification, Segmentation, Free space detection, Volume measurement...

4. **Reducing the required bandwidth and processing requirements** of the Application layers: the pre processor must provide only relevant data for the application at hand, dramatically decreasing its volume.

The processing layers

LiDAR pre-Processing software is a new participant in the 3D real-time value chain.

It provides an easy way to use LiDAR in any application.

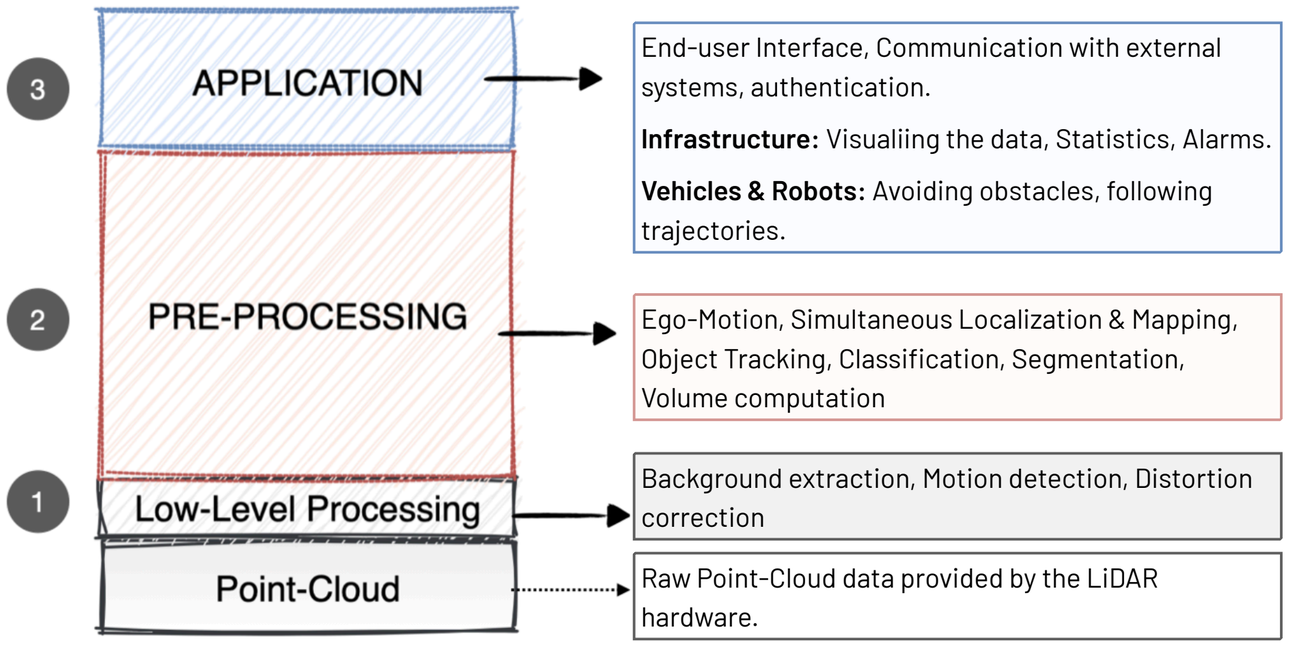
In general the software stack can be organized in 3 abstraction layers running on top of the basic point-cloud that the LiDAR hardware provides.

1. The Low-Level processing deals with points and delivers points (3D coordinates), for example to detect points belonging to the background (static objects) so those that are moving can be easily spotted.

2. The Pre-Processing layer is arguably the most difficult one, as it must fulfil the features that are required in most applications, regardless of the use case.

   It processes 3D point data and delivers actionable output (mostly in the form of Objects).

3. The Application Layer applies specific Business Logic based not on the point-cloud but in the Objects' output of the previous layer.



Top 10 reasons why you should use a 3D LiDAR pre-processor

LiDAR pre-processors offer several advantages over both in-house and third-party development options.

Get to market Faster

From plug in to deployment in minutes, not months

Pre-processing software allows you to use 3D LiDAR data in real-time by employing a comprehensive set of features and a seamless plug-and-play integration.

You can start building your solution from day one.

Visit our website www.outsight.ai to play a video showing how to get from first plugging your LiDAR to Object Tracking and Zones of Interest definition in 90 seconds, without installing any framework, library or software in your computer.

See the video at www.outsight.ai

Avoid Development Uncertainty

Starting from scratch is risky and inefficient

Pure LiDAR software players such as Outsight have years of experience implementing highly efficient LiDAR software in a range of environments.

Leveraging this experience ensures that you avoid the many pitfalls encountered by those building internal solutions.

Optimize Cost

No need to maintain a dedicated in-house team

Employing pre-processing software allows you to benefit from the work of a team of experts at a fraction of the cost of in-house or outsourced engineering.

Especially when accounting not only for the development time but also the maintenance cost.

Achieve World-Class Performance

Leverage the experience of LiDAR-focused teams

Building state-of-the-art 3D LiDAR real-time software is a full-time job for specialists. It requires a multi-disciplinary team that is hard to build in-house (Localization, Perception, Tracking, Embedded software, UI/UX, QA...)

Use the right LiDAR sensor

Not all LiDAR sensors are created equal

Using a LiDAR processing software that is already compatible with most if not all of the available LiDARs allows you to use the most appropriate sensor(s) for your application and environment.

Combine Different Sensors

Mix sensors for wider area and functional coverage

A combination of various LiDAR sensors, including products from different manufacturers, is often needed to produce the best results: doing so without pre-processing software is incredibly challenging and can lead to major project setbacks.

Be Different

Create a unique solution for your application

Pre-processing software doesn't replace the application-specific solution, which allows you to create unique products that are tailored to your specific needs and keep the associated full IP rights and value of what you built.

Optimise processing ressources

Save bandwidth and computational resources

When using the right LiDAR processing solution, Edge computing requirements must be as low as an ARM CPU, which drastically reduces the application's power and heat dissipation constraints.

Derisk supply chain uncertainty

Increase resiliance through hardware multi-sourcing

Being able to seamlessly use multiple hardware sources, both for processing and sensing, is becoming increasingly important in today's uncertain geopolitical situation.

Professional pre-processing software abstracts the hardware, reducing risks and allowing for easy hardware switching.

Use the most advanced tools

From planning to development and test

A 3D LiDAR processing solution's development lifecycle necessitates a variety of advanced tools, ranging from 3D simulation to data recording, annotation, and replay, not to mention quality assurance processes and tools.

A professional team providing pre-processing solutions allows all of their customers to benefit from the substantial investment required to build and maintain this pipeline.

Leverage Others' Experience

Benefit from cross-industry experience and solutions

Good pre-processing software comes with ready-to-use application examples that allows you to benefit from similar issues that have been solved in other industries and contexts.

What should you ask for from a LiDAR pre-processor?

It's useful for application developers to understand what the LiDAR state-of-the-art pre-processing solutions bring to the table

Top capabilities provided by the best 3D pre-Processing software

1. LiDAR agnostic
2. Single and multi-LiDAR setups
3. Allows prototyping and deployment
4. A comprehensive set of features
5. Works in most operating contexts
6. A modern SDK-less 3D interface
7. A RESTful API
8. An open and standard data format

1. LiDAR agnostic

While it's not actually possible and even useful to be fully compatible with any and all LiDAR sensor, a good 3D pre-processor must be able to accept input from at least 80% of the currently available models.

That is required in order to guarantee that application developers can use the best available solution, enable multi-sourcing in situations where requiring a robust supply chain is critical, and avoid vendor lock-in.

It's easier said than done since **there is no standard among manufacturers,** in the network, transport nor application layer, and there are **many different variables and combinations** to cope with :

Communication	TCP	UDP	Proprietary
Field of View	360º	<120º	Narrow FoV
Pattern	Fixed	Random	Dynamic
Frame-rate	10 Hz	20 Hz	SW Defined
Reflectivity	Yes	No	Calibrated
Hits per azimuth	Single	Double	Multiple
Range precision	High	Noisy	Variable

Outsight provides a LiDAR-agnostic software solution embedded in a plug and play Edge device.

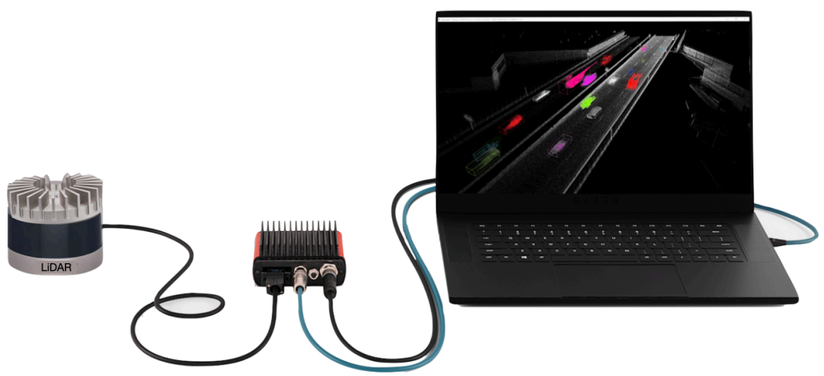
Learn more at outsight.ai

2. Single and multi-LiDAR setups.

Single LiDAR setup

When using a pre-processor with a single LiDAR data as an input, the setup should be straightforward —connecting your LiDAR to the Host computer with the pre-processing step between these two elements.

> The Outsight **Augmented LiDAR Box©** replaces the interface box of your LiDAR and embeds the real-time processing software.
>
> It also takes care of powering the LiDAR itself and manages the different voltage levels of each manufacturer*.



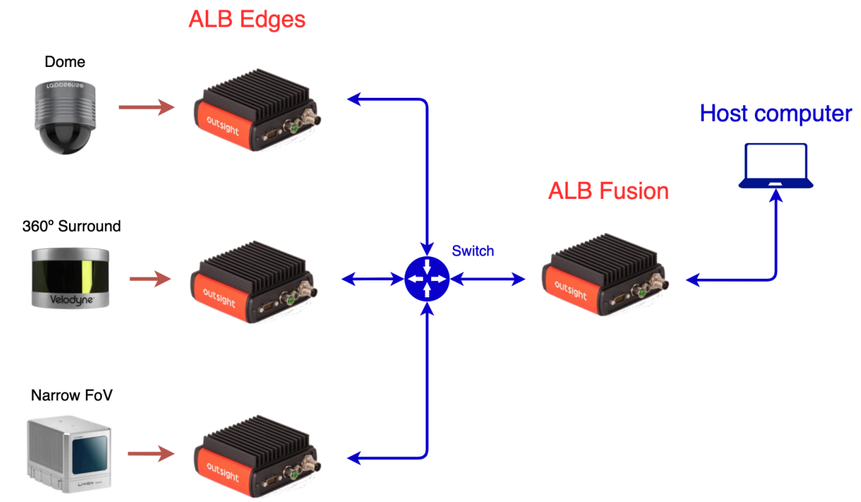
** Also in this aspect there is no standard in the market (12V, 19V, 24V, etc.), adding up to the long list of issues and complexity of integrating LiDAR into your project.*

Multi-LiDAR setup

In some situations, it can be necessary to fuse the information from different LiDARs.

For example, in traffic management systems, having multiple sensors allows coverage of wider areas while also minimising shadows and blind spots created by static or moving objects.

In these contexts, an additional **Augmented LiDAR Box** called Fusion can be used to merge the data from each sensor and create a super-sensor from the point of view of the application software.

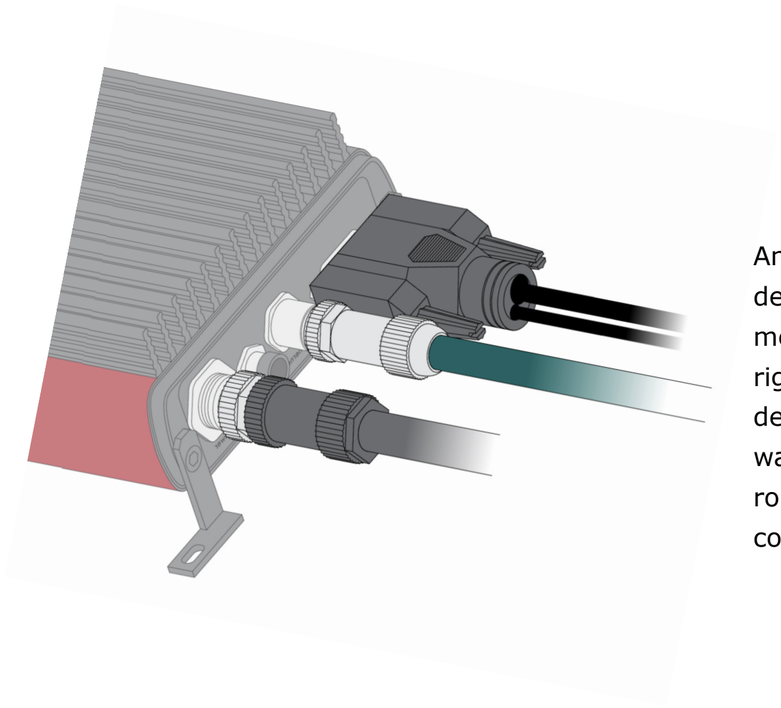


> Note that in many cases, the right solution for covering wide areas is to combine products from different manufacturers.
>
> The right pre-processing solution must abstract the application software from this complexity and provide a unified and standard output format regardless of the input.

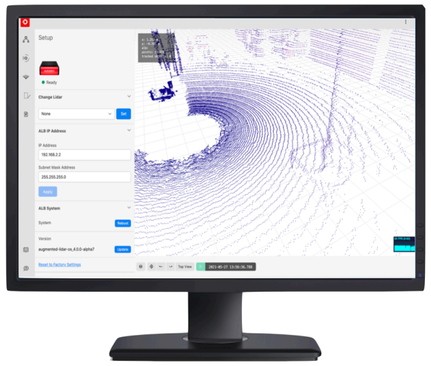
3. From prototyping to deployment

It is interesting that a LiDAR pre-processor allows you to quickly prototype new ideas and get results as quickly as possible.

It is also important to leverage your work in this early phase when it's time to deploy the solution at scale.

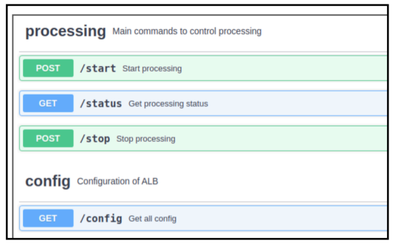


Anticipating the deployment at scale means also using the right processing Edge device, including waterproofness and robust industrial connectors.

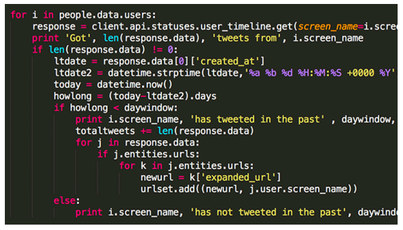


Jump start with and embedded 3D Player Engine.

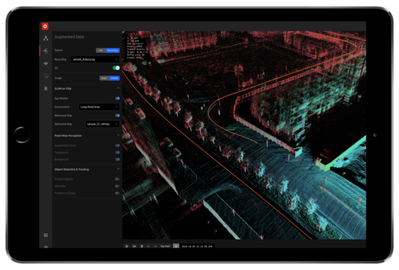
Discover and test what's possible, and get results in minutes.



Control your pre-processor with visual no-code API calls directly in your pre-processor.



When you're happy with the results, integrate the generated calls into your application.



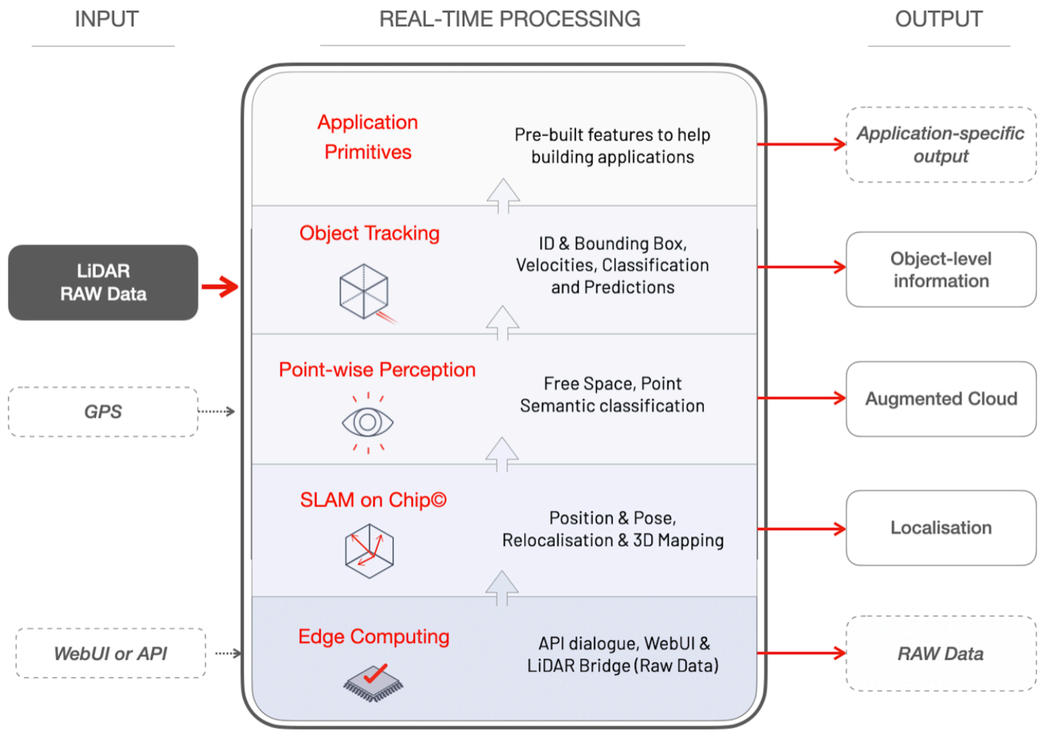
Deploy your solution in any device of your choice.

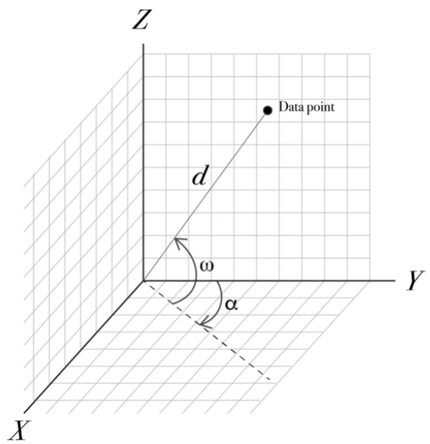
outsight

4. A comprehensive set of features

A state-of-the-art real-time LiDAR pre-processor is not only about a LiDAR abstraction layer, good interfaces, and sensor fusion capabilities.

As an application developer, you must also look for the deepest level of available features on top of which you can build a specific solution.





Not all 3D processing are created equal.

A good LiDAR pre-processor must leverage the full value of 3D; that is, deliver a 6 Degree of Freedom output (X,Y,Z and orientation on each axis).

Pre-processing is not a synonym of a black-box approach. The **Augmented LiDAR Box©** gives you access to the raw data and LiDAR configuration at any time, either for debugging purposes, algorithm redundancy, or low-level sensor fusion with external systems.

5. Works in most operating contexts

Sensor Kinematics

MOBILE

STATIC

Type of Scene

OUTDOORS

INDOORS

Environment

LAND

SEA

AIR

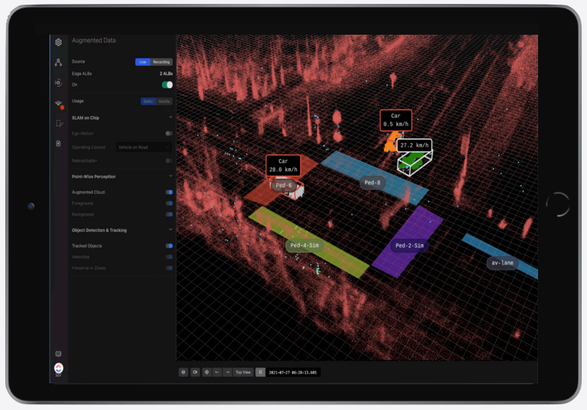
Visit our Video Center at outsight.ai to see many real-life examples

A LiDAR pre-processor must work with data originated from various host platforms in a diverse set of environments, both indoors and outdoors.

This has several implications:

- The pre-processor should not rely on *a priori* information such as being on a road or on a flat surface. While this can be good enough in automotive-only situations, it is not acceptable in a general-purpose 3D processor.
- It should work in a true 3D (6 Degree of Freedom) manner, which means including the orientation (roll, pitch, yaw) on each axis (x, y, z).
- It should handle relatively quick accelerations and high speed without requiring input from other sensors (i.e. Wheel encoders or IMU)
- Relying on environmental features (walls, racks, etc.) in order to perform operations such as SLAM is not acceptable. It must work in open environments (outdoor) and rough unstructured terrain.
- The same solution must work both when the LiDAR is mounted on moving platforms (vehicles, mobile robots) and static positions (smart infrastructure applications).

6. A modern SDK-less 3D Interface



An embedded 3D Web player on the Edge changes everything. You can now interact with your LiDAR pre-processor using a browser and your preferred device without installing any software.

You can process millions of 3D points per second in real-time.

No-code interface

In the early days of LiDAR, led by hardware manufacturers delivering raw data, the traditional approach to use 3D data was to propose that the user download a SDK and/or install or use a specific framework*, in some cases only working with a specific operating system and many dependencies.

While this was a good start, mainly for research and development purposes, it introduces a significant level of friction and complexity that requires specialized engineering time for non-value-added tasks.

When using a professional Lidar software pre-processor you should ask for a seamless no-code experience where the phases of Evaluating LiDAR hardware, Prototyping, Planning and Deploying can be done using a simple Web browser and a modern UI, without any specific software installation.

Outsight's answer to this need is the **Augmented Studio**, natively embedded in the **Augmented LiDAR Box©** pre-processor that allows you to configure it, visualize the output of all the available features in real-time and define and modify zones of interest among other things.

When you feel ready to tackle the most advanced features, you can jump to the alternative API method.

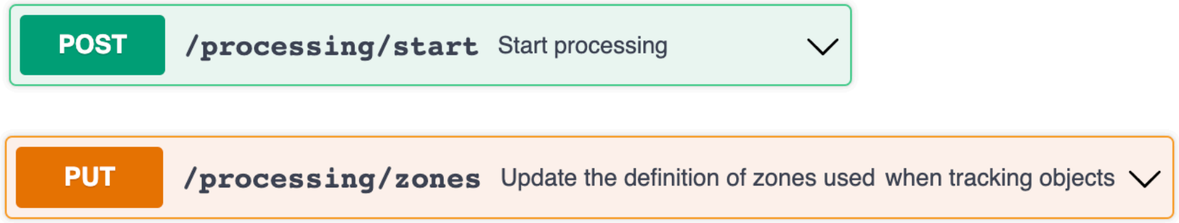
> See it in action: in this video we show you in only 90 seconds how to go from first plug in your LiDAR to start tracking objects.

** For example, in robotics research and development, ROS with Ubuntu Linux is widely used, which is not the case in many other professional fields.*

7. A RESTful API

LiDAR enters the API era

Controlling your pre-processor should be as simple as sending a REST API call.



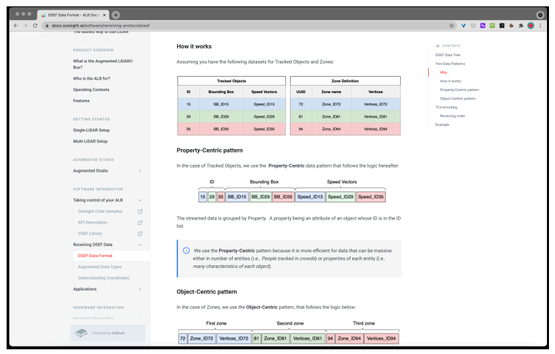
Abstracting the complexity of processing raw data from LiDAR and providing a standard layer of interaction with your LiDAR hardware are key fundamental features of any state-of-the-art 3D pre-processor.

Easily prototyping your API calls and experimenting with them before entering into production is an additional valuable feature.

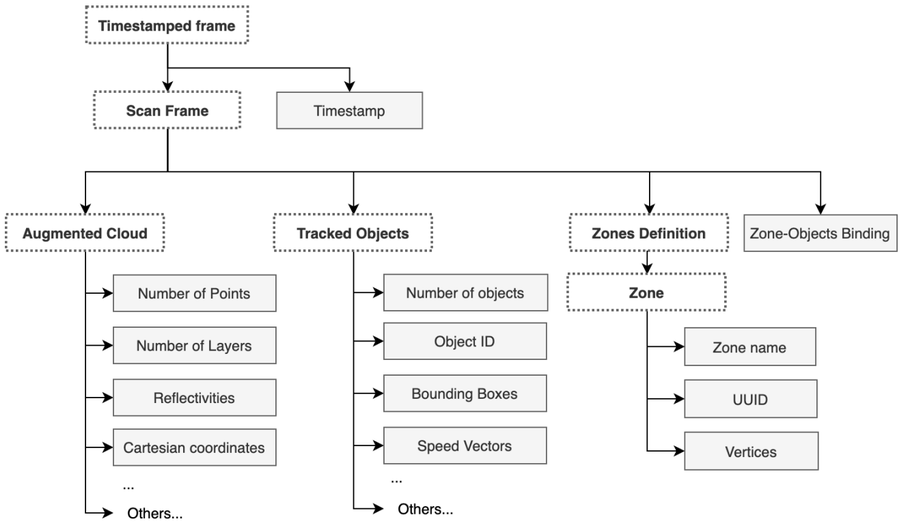
In the case of the **Augmented LiDAR Box©**, this is possible directly from the Web interface, making it even simpler to link the no-code graphical approach with a low-code API method.

Building your application also means you can directly interface the output of the 3D real-time processing on the Edge with any Cloud-Based service.

Request access to a detailed online documentation at outsight.ai



8. An open and standard data format



The **Augmented LiDAR Box©** delivers its output using OSEF, a serialization binary format, based on TLV-encoding.

For each processed LiDAR Frame —typically at 20 fps— the structure of the OSEF data is a tree that contains the timestamp information and all its attributes including Ego-Motion and Tracked Objects.

A data encoding scheme that grows with your needs

LiDAR proprietary data formats and protocols made sense when this emerging technology first appeared since it shortened the time to market of new hardware products delivering raw data. The burden of decoding each specific format was on the user.

For a LiDAR pre-processor to accomplish its purpose, it must provide an open data representation system with at least the following characteristics:

- Open: no proprietary IP or dependencies
- Simple: parsing it must be straightforward and efficient
- Robust: data elements can be placed in any order inside the message body
- Backwards-compatible so new features and data fields can be seamlessly added over time without compromising already-deployed applications (e.g., able to safely skip older or unknown elements)
- Efficient: to minimize both processing time and bandwidth
- Adaptable: must be able to react to user requests without changing its structure and decoding patterns, so only relevant data is sent
- Flexible: should be usable both for simple and small-sized data (e.g., the computed position of the sensor) and mass amounts of 3D information (e.g., the retransmitted point-cloud and associated attributes)

Conclusions

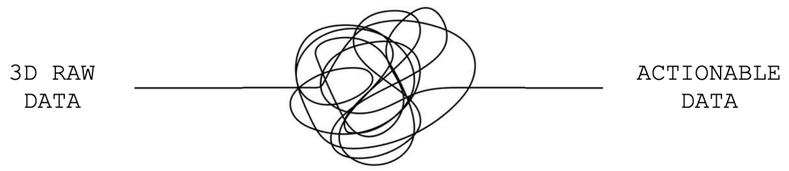
In order to become usable by everyone, LiDAR technology must evolve from its current status of ***a promising hardware component used by expert early adopters*** to a solution enabler that can be used by mainstream professional users.

That requires evolving from a hardware-centric approach, delivering raw data and surrounded by complexity, to software-enabled actionable insight.

A new category of products does exactly that: real-time 3D pre-processing software is here to stay and to empower a new generation of application developers to leverage the unique value of LiDAR data.

Software eats industries. LiDAR is next.

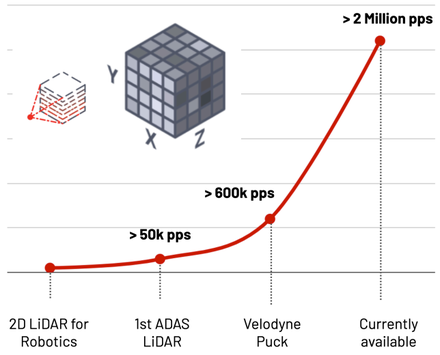
LiDAR hardware is a promising new technology, but it's complex to use and to integrate.



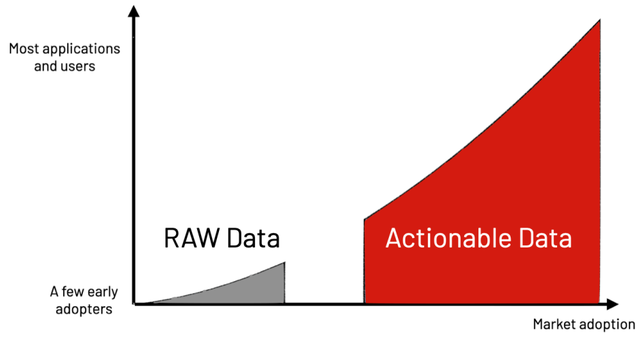
The industry is at its infancy. Many hardware manufacturers **that don't share any kind of standard** are competing fiercely, which is driving prices down very quickly, stimulating a strong demand in many markets and applications beyond automotive.

However, due to the unique nature of 3D data, which is very different from 2D images, most professionals find it **risky**, **long**, **expensive**, **defocusing**, and **inefficient** to develop a full-stack LiDAR software solution in-house or through subcontracting.

That becomes even harder when you consider that the massive amount of 3D data that must be processed in real-time is growing very quickly.



The purpose of a real-time 3D LiDAR pre-Processor is to abstract hardware complexity, providing **the easiest, safest, and smartest way to use LiDAR in any application.**



The easiest way to use LiDAR

We deliver Plug & Play Spatial Intelligence

> The **Augmented LiDAR Box©** is a convenient Edge device that embeds the pre-processing software in order to provide a seamless integration experience.
>
> Don't hesitate to contact us at outsight.ai for use of your own processing hardware or the Cloud.

Outsight's founders and team have been **pioneering real-time LiDAR processing for 17 years,** building transformative solutions in many customers' applications and contexts, arguably becoming one of the most experienced software pure players globally.

> **Our mission is to make LiDAR-based Spatial Intelligence become Plug & Play**, so it can be used by developers of applications in any market.

We've created the **Augmented LiDAR Box©**, the first software pre-processor for 3D data, that performs all the fundamental features you need to make your LiDAR-based project (3D SLAM, Object Detection and Tracking, Segmentation and Classification). With any LiDAR.

Our customers are builders of smart machines (mobile robots, vehicles, etc.) and infrastructure-based solution providers that monitor flows of people, goods, and vehicles (e.g., smart cities, industries, road safety, logistics, security, surveillance, etc.).

Our international team of scientists and engineers operates out of Paris, Helsinki, and San Francisco.

We believe that accelerating the adoption of LiDAR technology with easy-to-use and scalable pre-processing will highly contribute to creating transformative solutions and products that will make a smarter and safer world.

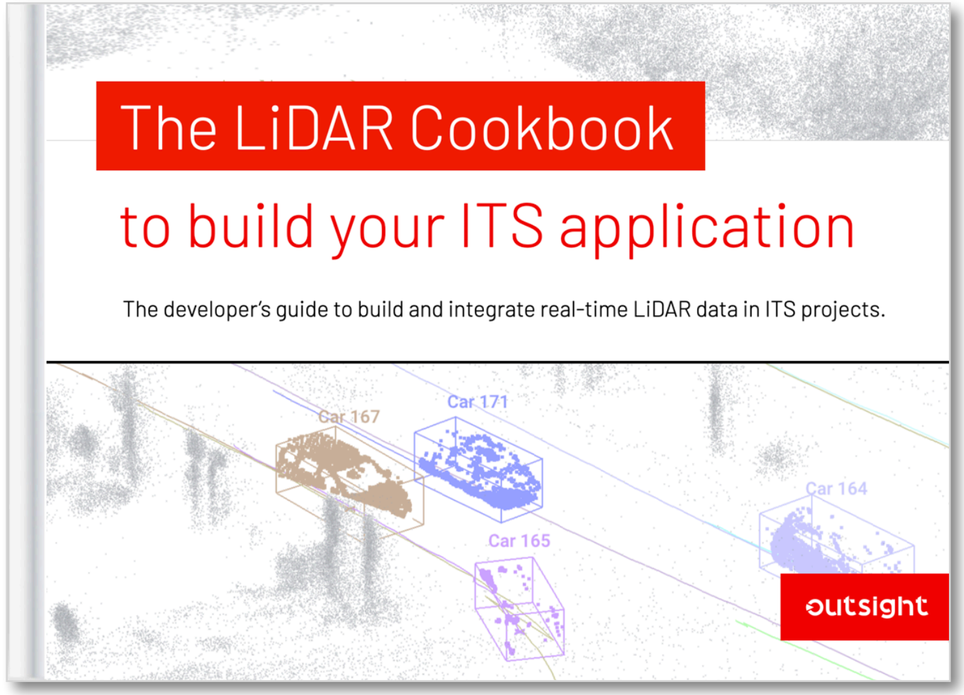
Additional resources

Make sure you read our ITS Cookbook

In this 40 pages-long e-book you'll find an actionable guide to build your own **Intelligent Transportation Systems'** solution using 3D LiDAR data.

You will also find inspiration for many other **Smart Infrastructure** projects.

Request access at www.outsight.ai

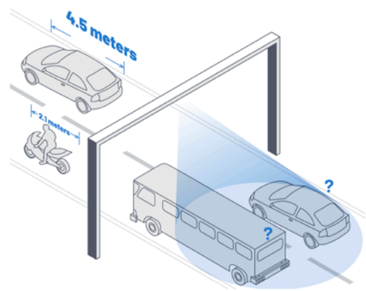


What's inside?

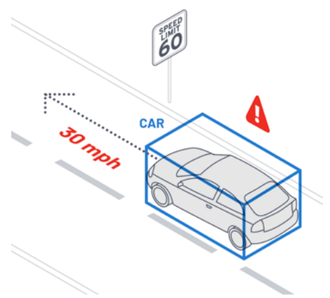
Each ***Recipe*** of the Cookbook describes a specific Use Case and is organized under three categories:

Pedestrians / VRU

Measuring and tolling



eed & Vehicle circulation



Using LiDAR
in real-time applications

To learn more, visit our website outsight.ai or follow Outsight on LinkedIn