Endless Possibilities with SLAM and 5G/Cloud Technology Together (Part 1)

3D-SLAM is of the instrumental technologies across several use-cases involving robotics, mapping, drones, autonomous vehicles, and AR/VR. Not second to any, the cloud and 5G communications are disrupting the technology industry with multiple use cases.

What possibilities can be unlocked if we can combine these two disruptive technologies in use cases?

At Kudan, we have already delivered multiple projects in the crossover: SLAM on the cloud and SLAM using 5G communications. This article will further explore and paint a clear picture of some of the problems that can be solved by the 3D-SLAM and 5G/cloud technologies.

As a first step, let's understand how these technologies can be combined in the use cases.

Understanding the crossover of SLAM and Cloud technology

Kudan Visual SLAM can run 5–10 times faster than other 3D SLAM algorithms (eg: ORB-SLAM2 on some Arm-based processors). Still, as it requires iteration of optimization using a large number of 3D point information, 3D-SLAM can be heavy and process-intensive for tight processing budget applications.

As a result, not all applications can afford the processing hardware that is suitable for 3D SLAM [1]. Often this acts as a blocker for adopting 3D SLAM for use cases. The ability to offload the SLAM process elsewhere can help adopt the technology into many more use cases.

Then cloud comes into play here. We can offload the SLAM process to the cloud. Let us explain through an example: for robotic applications, the robots can send the images from their sensors to the cloud. The SLAM process can now run on the cloud and send the information only regarding the poses back to the robot. The robot can use this information for its own control and motion.

This is truly disruptive and SLAM on the cloud already has significant potential to expand the usage of SLAM to multiple use cases. The figure 1 below does a great job of explaining the architecture in the usage of cloud alongside SLAM.

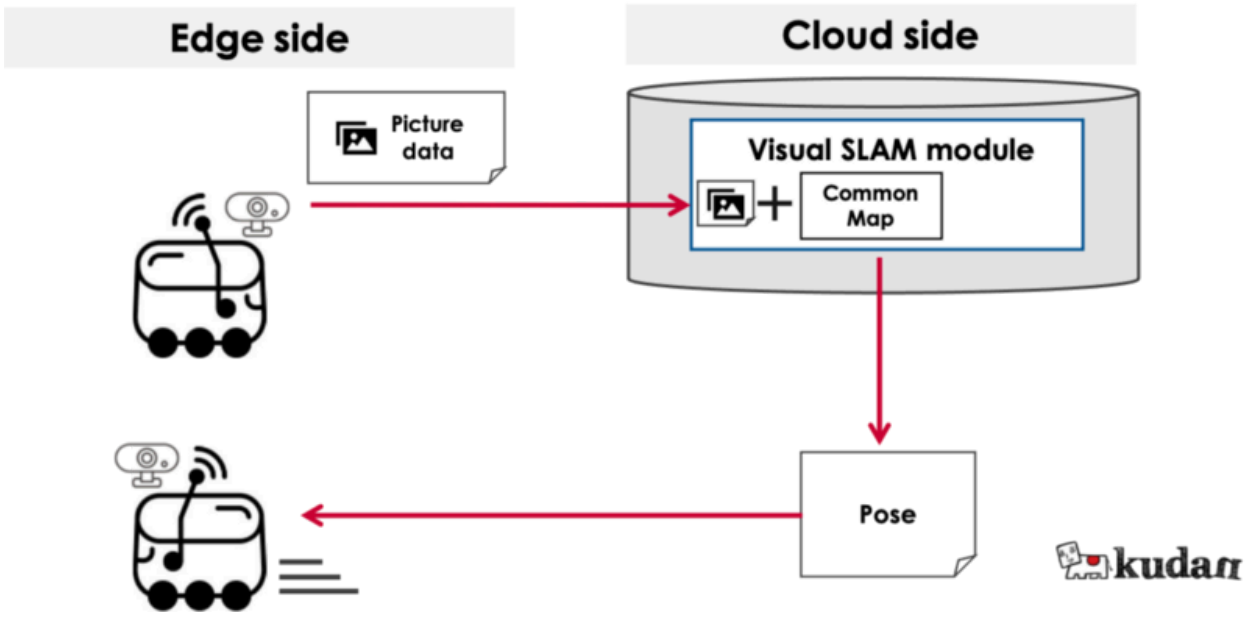

Figure 1: High-level architecture of Visual SLAM on the cloud.

Deteriorating accuracy and role of 5G communication technology

The problem we faced for some SLAM-on-cloud projects was the latency and robust connectivity that wasn't up to the mark when sending the image stream to the cloud and receiving the required information back.

For use cases requiring continuous pose information at 10Hz or more, this is crucial. And as a result, we experienced deteriorated accuracy and an increased risk of collision in the robots. We needed a way to communicate better between the robots and the cloud.

That's when 5G technologies becomes relevant with SLAM. It provides higher speeds, superior reliability, and negligible latency. In our context, image sequences from multiple robots can be sent through 5G technology without significant latency. It enabled the application to use low-cost, low-power hardware for edge devices while still benefiting from 3D SLAM features.

You probably have a good understanding of the architecture and the usage of both cloud and 5G technology for SLAM. Let's now visit a use-case example that leverage these technologies.

Use-case example: Autonomous Mobile Robots (AMRs)

Visual SLAM functionality can be added to an existing autonomous mobile robot (AMR) to make its localization performance more robust and stable.

Many AMRs use 2D-Lidar SLAM for localization. Though it shows acceptable performance for SLAM-friendly environments, it struggles in environments where the scenery is constantly changing or occasional outdoor operations such as between factories.

Visual SLAM has a clear advantage when fused with its 2D counterpart in these scenarios. Figure 2 illustrates how the Visual SLAM can be used with the cloud service.

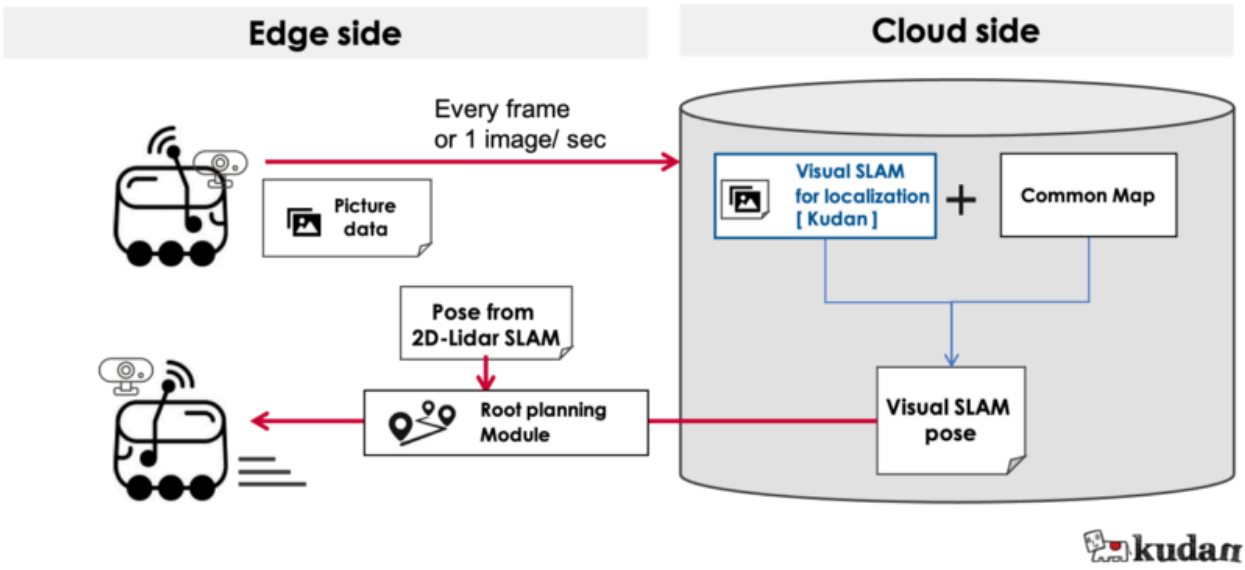

Figure 2: High-level architecture of Visual SLAM on cloud example in robotics applications.

As shown in the architecture above, you can obtain the pose from Visual SLAM through the cloud and fuse it with 2D-Lidar SLAM pose to get more redundancy.

The frequency of sending images can be flexible depending on the purpose of Visual SLAM and the availability of 5G.

In instances where there is a good 5G network available, you may send an image stream at 30 frames per second (FPS). When not available, you may send an image every second (1 FPS) and use it as an aiding approach on top of 2D-Lidar SLAM.

Another option is to dynamically change between Visual SLAM and 2D Lidar SLAM; for instance, when the robot is outdoor, it sends images more frequently so that it can rely solely on Visual SLAM, and when indoors, it sends at a lower frequency indoors to limit network usage.

As you can see, you suddenly have many options to enhance the system's overall performance.

Final words

Did you really think that's all the use case examples of SLAM with 5G/Cloud? There's plenty more. But let's stop here for now as we already introduced many new ideas around 3D SLAM.

Many more practical examples will be discussed in more detail in part 2 of this article which includes examples from Visual positioning and autonomous driving. So you can have an even more detailed understanding of the applications of SLAM. Stay tuned!

Meanwhile, feel free to say hi, and we'd be happy to help you transform your business through our SLAM solutions!

References

[1] Kamburugamuve, S., He, H. & Fox, G. and Crandall, D. (2016). Cloud-based Parallel Implementation of SLAM for Mobile Robots. [PDF]