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Kudan Inc.

Published a blog post on GNSS deterioration due to recent solar activities and the effectiveness of SLAM as a countermeasure

Kudan Inc. (headquartered in Shibuya-ku, Tokyo; CEO Daiu Ko, hereafter "Kudan"), a leading provider of Artificial Perception / SLAM technology across a variety of applications, is pleased to announce that we have published our blog post (see the attached below) titled "How to Tackle GNSS Deterioration Due to Recent Solar Activities."

In recent years, increased solar activity and the resulting disruptions to social infrastructure have been pointed out. This blog post explains the impact of this increased solar activity and proposes the need to introduce multiple approaches that do not solely rely on GNSS as the positioning system as well as the effectiveness of SLAM as the redundancy system, which can act as the fail-safe mechanism when the GNSS signals aren't available.

About Kudan Inc.

Kudan (Tokyo Stock Exchange securities code: 4425) is a deep tech research and development company specializing in algorithms for artificial perception (AP). As a complement to artificial intelligence (AI), AP functions allow machines to develop autonomy. Currently, Kudan is using its high-level technical innovation to explore business areas based on its own milestone models established for deep tech which provide wide-ranging impact on several major industrial fields.
For more information, please refer to Kudan's website at https://www.kudan.io/.

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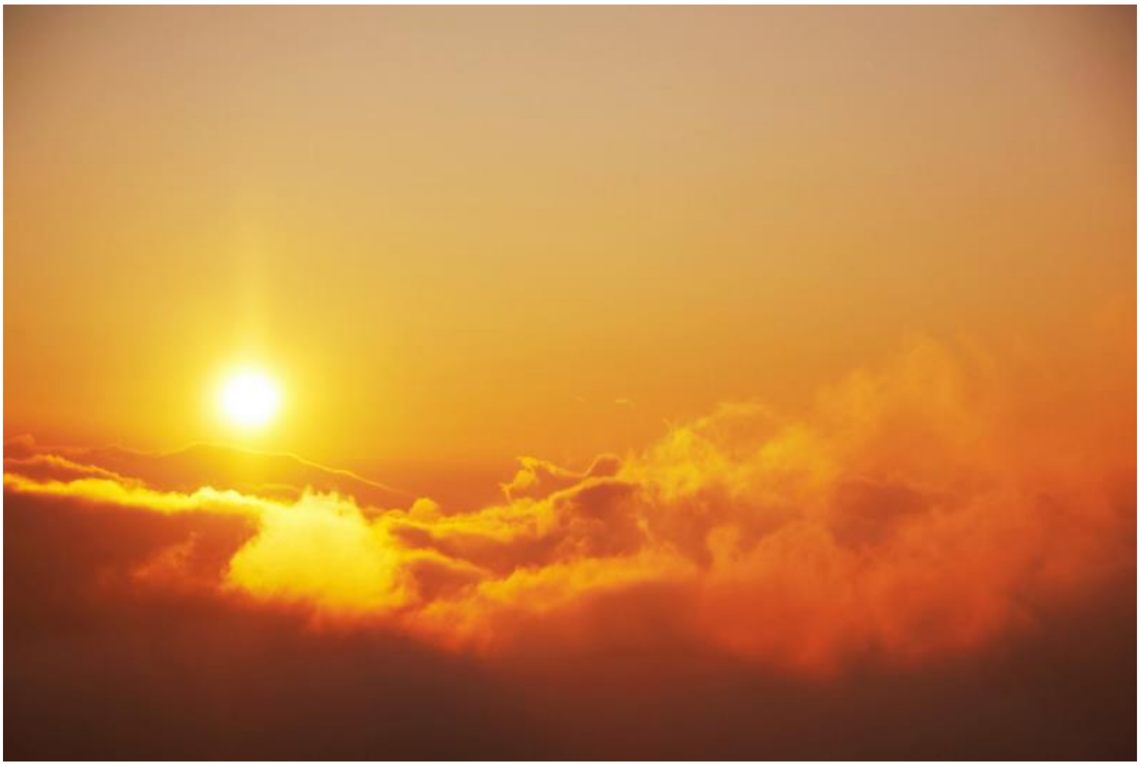
How to Tackle GNSS Deterioration Due to Recent Solar Activities



According to the European Union Agency for the Space Programme (EUSPA), the Global Navigation Satellite System (GNSS) refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The electronic devices with appropriate receivers can use this data to determine their precise location on the earth's surface.

The GNSS system can determine the receiver's position with an approximate several meters accuracy. One of the most common further improvements to this technology is RTK-GNSS (Real-time Kinematic), which can increase the position accuracy to about 1–4 cm.

Some outdoor autonomous vehicles, such as autonomous mining trucks, agricultural robots, mapping solutions, and more, use the GNSS, especially RTK-GNSS. When the signal quality is strong, we can detect these vehicles with several cm accuracies.

The Problem: What happened to the GNSS?

Despite GNSS being able to accurately position autonomous vehicles, in the recent past, we have been approached by companies using GNSS and RTK-GNSS for their applications. They have relied on RTK-GNSS to position their vehicles over the last years. However, recently they have been experiencing continuous disruptions in the GNSS signals. When these GNSS signals are unavailable, it causes the vehicles to stop operationing and they have to wait until the signals recover; costing their business significantly.

Companies can't anymore solely rely on GNSS as their positioning systems.

Why is this happening?

The Reasoning: Why isn't the GNSS reliable?

The disruptions to the GNSS signals can be linked to the increased solar activity in the past. In simpler terms, here's the detailed explanation of why it's been happening.

Like every other star, there are regular explosions of vast bursts of material, referred to as solar activities. A constant increase in solar activity has been recorded in the past months and is expected to increase even further in the coming years.

According to EUSPA, cyclical variations in the solar magnetic field can be experienced approximately every eleven years. The latest solar cycle, 25, started in December of 2019 and is expected to maximize its impact between 2023 and 2026.

The graph below from the Space Weather Prediction Center details the solar cycles and the expected timeline better:

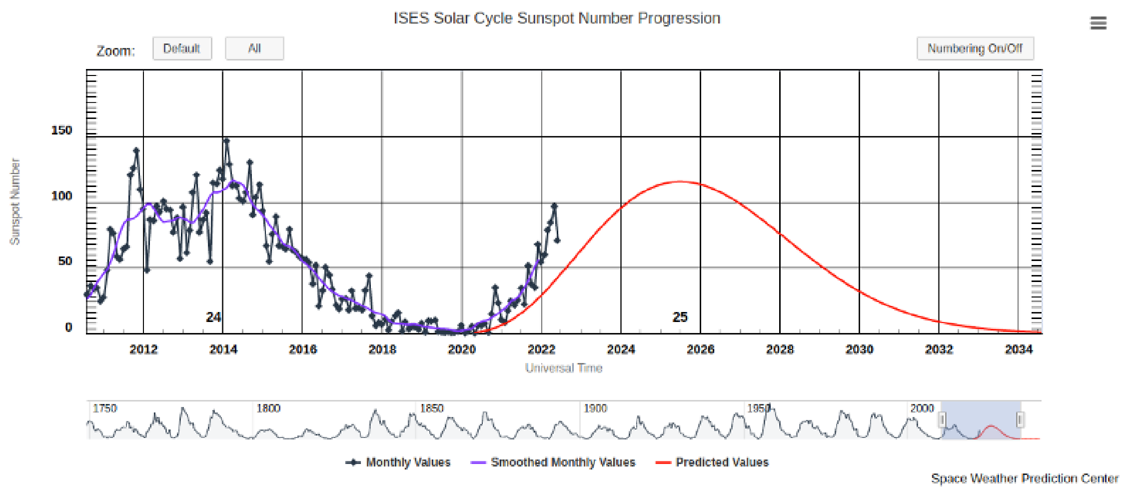


Figure 2: Solar cycle progression

Now that we understand that solar activities peak every several years, how do they impact communication systems such as GNSS?

As we know, the GNSS receiver determines its location through signals emitted from the satellites orbiting the earth. These signals travel about 20,000 km to Earth and are mostly unhindered. The distortions and delays in these signals occur due to the refraction and diffraction of the signals in the earth's atmosphere—especially within the ionosphere.

According to NASA, the ionosphere is where the atmosphere meets space and is the home to all charged particles in the Earth's atmosphere.

GNSS receivers typically consider the effect of charged particles on the satellite signal using modeling techniques when the charged particles are homogeneously distributed. Increased solar activities, however, cause fluctuations in the ionosphere's electron density, distorting the amplitude and phase of the GNSS signals.

This phenomenon is called scintillations. Due to irregular distortions, the standard GNSS receiver can't handle such strong scintillation events. Mild scintillation causes several meters of inaccuracy, and severe scintillation may result in cycle slips or, worse, a complete signal loss.

This was precisely the scenario faced by the major mining machinery provider we saw earlier. The localization systems we use must be robust to handle the possibility of deteriorating GNSS, especially since such scenarios are expected to repeat in the future.

So how can we mitigate the impact of solar activities on the GNSS?

The solution: Can SLAM help?

The first option in overcoming the disruptions to GNSS signals is to look for advanced GNSS systems [1] that are more robust against the above mentioned scenarios. Systems with advanced receivers can continue tracking signals in conditions that challenge the standard receivers.

However, if you want to countermeasure it fundamentally, you must introduce redundancy in the positioning system. We recommend using 3D SLAM as the redundancy system, which can act as the fail-safe mechanism when the GNSS signals aren't available [2].

3D SLAM only requires camera images or 3D-Lidar point clouds to function accurately in an outdoor setting.

For wide-open spaces such as mining sites, farming fields, and parking lots with ample parking spaces, Visual SLAM has an advantage over 3D-Lidar SLAM. 3D-Lidar SLAM requires detecting a meaningful amount of objects around the sensor which couldn't be the case for wide-open spaces like the above. Visual SLAM can use visual features to keep tracking in such areas. However, in scenarios with objects within the 50m-100m range or during nighttime, 3D-Lidar SLAM provides better accuracy and robustness.

The ultimate solution would be to fuse a camera and a 3D-Lidar with the GNSS and other sensors. In the long run, this solution would ensure a reliable, robust, and accurate positioning system for your use cases.

If you notice performance issues on your existing GNSS-based positioning system, consider that it could be for the reasons that we've shared about, and get in touch with us. We will be able to propose a customized SLAM-based solution to bring back the accuracy and performance that your application needs while eliminating any operational downtime from such disruptions.

References

[1] Petovello, Mark & O'Driscoll, Cillian & Lachapelle, Gérard & Borio, Daniele & Murtaza, Hasan. (2008). Architecture and Benefits of an Advanced GNSS Software Receiver. Positioning. 1. 66–78. 10.5081/jgps.7.2.156. [PDF]

[2] Gong, Zheng & Ying, Rendong & Fei, Wen & Qian, Jiuchao & Liu, Peilin. (2019). Tightly Coupled Integration of GNSS and Vision SLAM Using 10-DoF Optimization on Manifold. IEEE Sensors Journal. PP. 1–1. 10.1109/JSEN.2019.2935387. [PDF]