Top Level Newsletter: Connected Vehicle

(Published by IEEE Orange County Section)

January 2023
Volume 36.0

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Systems Research Development and Innovation

Vol 36: This issue includes articles on cellular localization and on autonomous electric vehicles:

(1) Cellular Localization for Autonomous Driving
(2) Baidu and Geely Will Mass Produce an Autonomous EV

General Notes

This series of newsletters is intended to provide the IEEE member with a top level briefing of the many different subjects relevant to the research, development and innovation of the connected vehicle.

The objective is to provide a platform for fast learning and quick overview so that the reader may be guided to the next levels of detail and gain insight into correlations between the entries to enable growth of the technology. Intended audiences are those that desire a quick introduction to the subject and who may wish to take it further and deepen their knowledge. This includes those in industry, academia or government and the public at large. Descriptions will include a range of flavors from technical detail to broad industry and administrative issues. A (soft) limit of 300 to 600 words is usually set for each entry, but not rigorously exercised.

As descriptions are not exhaustive, hyperlinks are occasionally provided to give the reader a first means of delving into the next level of detail. The reader is encouraged to develop a first level understanding of the topic in view. The emphasis is on brief, clear and contained text. There will be no diagrams in order to keep the publication concise and podcast-friendly. Related topics in the case of Connected Vehicle technology, such as 5G cellular and the Internet of Things will be included. The terms Connected Vehicle and Automated Driving will be used inter-changeably. Articles from other published sources than IEEE that add to the information value will occasionally be included.

This newsletter forms part of the regional Advanced Technology Initiative (ATI) of which connected vehicles form a constituent part. Technical articles solely from IEEE journals/magazines are referred to by their Digital Object Identifier (DOI) or corresponding https link. The link for each article is provided. Those readers who wish to delve further to the complete paper and have access to IEEE Explore (www.ieeexplore.ieee.org) may download complete articles of interest. Those who subscribe to the relevant IEEE society and receive the journal may already have physical or electronic copies. In case of difficulty please contact the editor at kaydas@mac.com. The objective is to provide *top level guidance* on the subject of interest. As this is a collection of summaries of already published articles and serves to further widen audiences for the benefit of each publication, no copyright issues are foreseen.

Readers are encouraged to develop their own onward sources of information, discover and draw inferences, join the dots, and further develop the technology. Entries in the newsletter are normally either editorials or summaries or abstracts of articles. Where a deepening of knowledge is desired, reading the full article is recommended.

1. **Cellular Localization for Autonomous Driving (RUSS WHITON)**

Published in: IEEE Vehicular Technology Magazine (Volume 17 Issue 4 December 2022, pp 28-37)

Abstract: Cellular localization has received marked attention in academia and in industry, as indicated by a rapidly expanding volume of literature specific to vehicular environments. Impressive results have been shown

for a number of problems as measured by metrics such as accuracy and latency. This article identifies five important requirements for cellular localization for safety-critical systems with a particular focus on autonomous driving (AD) and puts them in the context of industrial and academic trends and standardization. We show why autonomous operation requires special consideration and suggest research directions toward novel and practically implementable solutions, drawing lessons from decades of work on satellite-based localization for aviation landing systems. In addition, we highlight the benefit of cellular localization technology for safety-critical autonomous systems, showing the utility of a satellite-navigation independent absolute localization sensor with error overbounding.

Background: The challenge of AD has resulted in a surge of industrial activity and academic publications in the past 10 years. Novel proposals have been made for the associated hardware and software components, system architectures and even behavioral and societal impacts. Using the levels defined in the Society of Automotive Engineers' (SAE) widely used J3016 taxonomy, companies, universities, and research institutes are now developing, testing, and validating levels 3 and 4 automated driving features on public roads. Functional architectures for AD are typically split into blocks from sensing through to actuation, enabling the vehicle to navigate the environment both on a large scale (lane selection and route planning) as well as on a small scale (lane position and orientation). This is most frequently accomplished with a broad suite of sensing technologies and a world map. Localization entails determination of position, orientation, and velocity in an external reference frame, and provides context to AD beyond the horizon of the perception sensors. This context can be provided with a world map, which can be as simple as a road-level navigation map or as intricate as a high-definition (HD) map rich with detail about road classification, lane markings, signs, and other detectable objects.
Only global navigational satellite systems (GNSSs) provide absolute estimates of position at coordinates surveyed in the same global reference frame in which map data are typically stored. GNSS has well-known limitations, primarily a strong dependence on physical view of satellites, weak signals at the Earth's surface, and is increasingly easy to jam and spoof by unsophisticated malicious actors.

Cellular localization has been developed as an enabling technology for use cases ranging from factory automation to AD, recognized in industry consortia such as the 5G Automotive Alliance and Third-Generation Partnership Project (3GPP). The communications world sees the natural affinity for cellular systems with their widespread deployment, relatively high power, and large communication bandwidth and granular direction determination to address localization needs for increased robustness and for expansion of the operational design domain to locations where GNSS reliability is always low, such as urban canyons.

To take the next step toward deployment of cellular localization for safety-critical systems including AD, we believe it is necessary to take a function pull approach, in which the needs of the AD localization subsystem, and the role of cellular localization within that subsystem, are considered from an application and safety engineering standpoint. This is done in accordance with automotive industry-wide technical standards that allow safety principles to be shared across engineering teams with common vocabulary and practices. In doing so, we place new types of requirements on cellular localization that have not been addressed in prior literature, which has considered the technology push of cellular localization within the architecture of cellular networks in terms of signals, operating frequencies, and bandwidths, or the performance achievable in isolation for automotive use cases without regard to sensor fusion or safety engineering principles, quantified by metrics like accuracy and latency.

We highlight performance metrics that we see would be most valued for AD, primarily the ability to establish quantified confidence in a localization solution in a reference frame that can be aligned with maps. We also show why multipath propagation poses difficult challenges for classic overbounding approaches adapted from aviation, and more generally the extent to which error overbounding can be ported from aviation landing systems to automotive use cases.

New constellations of researchers across disciplines are necessary to achieve this vision. This encompasses the fields of classical navigation, different subdisciplines of wireless communications, geodesy, as well as safety engineering. To this end, we offer a list of research topics that need to be addressed to realize such a solution, drawing lessons from decades of work done on localization integrity in aviation.

The manuscript is organized as follows: First, an introduction of AD localization architectures, safety-critical localization, and the state of cellular localization in literature and standardization is presented. The following three sections then identify novel requirements related to the gaps between the *pull* of AD functional needs and the *push* of cellular localization technology, formulating requirements and exploring the reasoning behind them. Finally, we conclude with an overview of the requirements and the functional benefits of their eventual realization.

(1350 words).

DOI: https://doi.org/10.1109/MVT.2022.3208392

2. **(Chinese Firms) Baidu and Geely Will Mass Produce an Autonomous EV (Craig Smith)**

Published in: IEEE Spectrum Magazine (Volume 60 Issue 1, January 2022, pp 36-37)

Last October a startup called Jidu Automotive, backed by Chinese AI giant Baidu and Chinese carmaker Geely, officially released an autonomous electric car, the Robo-01 Lunar Edition. In 2023, the car will go on sale.

At roughly US $55,000, the Robo-01 Lunar Edition is a limited edition, cobranded with China's Lunar Exploration Project. It has 2 lidars, 5 millimeter-wave radars, 12 ultrasonic sensors, and 12 high-definition cameras. It is the first vehicle to offer on-board, AI-assisted voice recognition, with spoken responses returned within 700 milliseconds, thanks to the Qualcomm Snapdragon 8295 chip "It's a car, and, even more so, a robot," said Jidu CEO Joe Xia, during the live-streamed unveiling of the car (as translated from the Mandarin by CNBC). He added that it "can become the standard for self-driving cars."

But just how autonomous the car is remains to be seen: In January 2022, Baidu and Jidu said the car would have Level 4 autonomous-driving capability, which does not require a human driver to control the vehicle. But the press release at the car's launch made no mention of Level 4, saying only that the car offered "high-level autonomous driving."

The blurred language may have been dictated by lawyers. China has yet to establish laws or regulations governing autonomous vehicles for the consumer market. For the time being, a driver must remain in control of the car. In September 2022, Baidu cofounder and CEO Robin Linoted that lower levels of autonomy shield car companies from liability in the event of a crash, because the driver is expected to be in control. With Level 4, the manufacturer of the car or the operator of the “robotaxi” service using the car would be to blame.

Nonetheless, the Robo-01 launch signals a dramatic shift in the automotive industry, which has been slow to adopt electric cars and even slower to embrace autonomy. No other consumer car on the market yet offers Level 4 autonomy. Tesla's Full Self Driving ability, despite its fancy name and the pronouncements of its CEO, is only Level 2, or “partial automated driving” under the definition of SAE International (formerly the Society of Automotive Engineers). Other autonomous-vehicle makers, including Tesla, are collecting data from mass-produced L2 vehicles to train L4 algorithms.

Meanwhile, Mercedes-Benz is offering its Drive Pilot Level 3 autonomous-driving system on S-Class and EQS sedans in Germany. Level 3 handles all aspects of driving, but it requires that the driver remain ready to regain control if requested. Drivers need not keep their eyes on the road, but Drive Pilot will disengage if the driver's face is obscured.

That raises the question of what Robo-01 can do that the Mercedes Drive Pilot cannot. And what features will Robo-01 use to keep drivers' hands on the wheel, as required under current Chinese law? Answers to those questions may have to wait until Robo-01 ships.
Regardless of the car's official autonomy designation, Baidu has billed its self-driving package, Apollo, as having Level4 capabilities. That includes what the company calls a Point-to-Point Autopilot, designed to handle highway, city street, and parking scenarios. Jidu is conducting further tests in Beijing and Shanghai to ensure that its Point-to-Point Autopilot will cover all major cities in China.

Chinese regulations do allow Level 4 in robotaxis that operate within designated geofenced areas, and Apollo has already shown what it can do in Baidu's Apollo Go robotaxis, which have provided more than 1 million rides in at least 10 cities across China. Baidu recently unveiled its latest autonomous robotaxi, the Level 4 Apollo RT6, which has a detachable steering wheel. The absence of a steering wheel is a statement in itself, and it frees up cabin space for extra seating or even desktops, gaming consoles, and vending machines.

China could well become the world's largest market for autonomous vehicles, with fully autonomous vehicles accounting for more than 40 percent of the country's new vehicle sales in 2040, and 12 percent of the vehicle installed base, according to global consulting firm McKinsey.

In 2018, China's Ministry of Industry and Information Technology, together with the Ministry of Public Security and the Ministry of Transportation, published standards for setting up road-test facilities for intelligent automobiles. Soon after, provinces and cities across China began setting up their own road-testing facilities.

Of the many Chinese companies already preparing to enter the autonomous-vehicle market, Baidu is the biggest player. Its Apollo open-source software-development platform launched in 2017. Two years later, the company was granted the first Level 4 road-test licenses in the country. More recently it received fully driverless permits in Wuhan and Chongqing, making Baidu the only company of its kind in

China to provide ride-hailing services without any human drivers present in the car, as Waymo does in Phoenix and Cruise does in San Francisco. Meanwhile, its Abolong L4 Autonomous Bus is operating commercially in enclosed campuses in at least 24 Chinese cities.

The Robo-01 is powered by a 100-kilo-watt-hour lithium battery from Chinese battery manufacturer Contemporary Amperex Technology Co., or CATL. It can accelerate from 0 to 60 miles per hour (97 kilometers per hour) in about 4 seconds and can go 600 km on a charge.
So, the car can drive far, and it can drive fast. But can it drive itself? We'll find out in 2023.
(880 words)

DOI: https://doi.org/10.1109/MSPEC.2023.10006688