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Rapid 3D Building Mapping Using An iPhone LIDAR Sensor to Support Sustainable Insfrastructure Digitalization in Line with SDGs 9 And 11: A Case Study Of SMP Negeri 2 Bangsal, Indonesia

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ABSTRACT

Technological advancements have driven a shift from manual to automated mapping methods, one of which is through the use of LiDAR (Light Detection and Ranging) technology. This technology enables fast and accurate three-dimensional (3D) mapping, especially in hard-to-reach areas. In the field of education, accurate spatial data is essential to support the Adiwiyata program, which emphasizes environmentally friendly and sustainable school spatial planning. This study aims to produce a 2D map of the SMP Negeri 2 Bangsal building as part of support for the program. The method used is rapid 3D mapping with a LiDAR sensor on the iPhone 15 Pro Max using a Research and Development (R&D) approach, involving data collection, planning, and development stages. Scanning was conducted dynamically across six zones based on room function. The point cloud data was cleaned using CloudCompare software, then reconstructed into a 3D model and converted into a 2D format using AutoCAD. The results show that mobile LiDAR technology offers a fast, efficient, and reasonably accurate solution for school infrastructure mapping. The resulting map supports green space management and the layout of educational facilities in a more effective and sustainable manner.

INTRODUCTION

The advancement of digital technology has significantly transformed mapping practices, shifting from traditional manual methods to more efficient and accurate automated systems. One of the most impactful innovations is LiDAR (Light Detection and Ranging), which utilizes laser beams to measure distances and generate 3D point clouds. This technology enables precise and rapid mapping, especially in areas that are difficult to access physically (Zimmer et al., 2023).

In the field of education, spatial mapping plays an important role, particularly in supporting environmental programs such as Adiwiyata—an Indonesian government initiative promoting sustainable and green schools. However, many schools still face limitations in implementing effective mapping due to lack of trained personnel, proper equipment, and continued reliance on conventional methods .

To address these limitations, mobile LiDAR technology presents an ideal solution. It allows for fast and reliable 3D mapping, even in challenging environments like densely built or vegetated areas. A study by (Yuda, 2022) demonstrated the success of LiDAR sensors on the iPad Pro in mapping historical buildings accurately and affordably. This method can also be adapted for mapping school environments in a practical and user-friendly way.

SMP Negeri 2 Bangsal, an active participant in the Adiwiyata program, requires detailed spatial data for effective management of green spaces, public areas, and evacuation routes. The use of LiDAR sensors on the iPhone enables rapid and precise 3D mapping across six designated zones. The resulting data supports more structured and sustainable spatial planning within the school (Pelita & Widodo, 2020; Rahmawati & Arifin, 2021).

Rapid 3D mapping is a technique that utilizes digital technology and remote sensing to generate three-dimensional models of an area in a short amount of time. This technology is applied across various fields such as tourism mapping, environmental surveys, and disaster mitigation. One commonly used method is drone-based photogrammetry and LiDAR technology (Kang et al., 2020).

LiDAR (Light Detection and Ranging) is one of the most effective methods for rapid 3D mapping. It uses laser beams to measure the distance between the sensor and objects, creating a "point cloud" that represents the three-dimensional structure of the mapped area. This technology can produce accurate data in a short time, making it highly efficient for large-scale projects that require detailed mapping within a limited timeframe (Dhruwa & Garg, 2023; Suzuki et al., 2021; Wei et al., 2022).

A building is a man-made structure designed for human occupancy or use, including residential, commercial, educational, or infrastructural functions. Buildings are essential components of urban environments and reflect a society's economic, cultural, and historical development. In urban planning, buildings not only provide shelter or utility but also contribute to shaping public space and urban identity (Skuppin et al., 2022).

LiDAR (Light Detection and Ranging) is a technology that uses laser beams to measure distances to objects with high accuracy. The integration of LiDAR into mobile devices such as iPhones and iPad Pros enables users to scan and map their surrounding environment in three-dimensional (3D) formats. This technology works by emitting laser pulses that are reflected by nearby objects, allowing the device to calculate distance based on the time it takes for the light to return (Luetzenburg et al., 2024).

Mobile LiDAR has been shown to be highly efficient and accurate for rapid 3D modeling in both indoor and outdoor environments. It offers a low-cost and user-friendly alternative to traditional 3D scanning methods, supporting applications in environmental surveying, heritage preservation, and urban planning (Askar & Sternberg, 2023; Kottner et al., 2023; Mehendale & Neoge, 2020).

The advancement of digitalization strongly supports the achievement of the Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 11 (Sustainable Cities and Communities). Digitalization enhances efficiency and innovation in both public services and industry through the use of digital technologies such as digital mapping, the Internet of Things (IoT), and process automation (Aziz et al., 2025). These technologies strengthen resilient, efficient, and inclusive infrastructure—the core focus of SDG 9.

Meanwhile, SDG 11 emphasizes the development of inclusive, safe, and resilient cities. Digital technologies such as Digital Twin systems, 3D mapping, and spatial data play a key role in smart city planning and disaster mitigation, as well as enhancing community engagement in urban governance (Patel et al., 2024). In other words, digitalization is not only about improving efficiency but also serves as a strategic tool for promoting urban sustainability and inclusivity.

RESEARCH METHOD

In this study, the author applied the Research and Development (R&D) method. According to the development model by Borg & Gall (1983), research and development is defined as follows: "*Educational Research and Development (R&D) is a process used to develop and validate educational products. The steps of this process are usually referred to as the R&D cycle, which consists of studying research findings pertinent to the product to be developed, developing the products based on these findings, field testing it in the setting where it will be used eventually, and revising it to correct the deficiencies found in the field-testing stage. In more rigorous programs of R&D, this cycle is repeated until the field-test data indicate that the product meets its behaviorally defined objectives.*"

There are ten stages in this model: (1) Research And Information Collecting, (2) Planning, (3) Development, (4) Preliminary Field Testing, (5) Main Product Revision, (6) Main Field Testing, (7) Operational Product Revision, (8) Operational Field Testing, (9) Final Product Revision, And (10) Implementation. However, in this study, the author only applied the first three stages: (1) Research And Information Collecting, (2) Planning, And (3) Development.

RESULTS AND DISCUSSION

A. Data Collection and Analysis Results

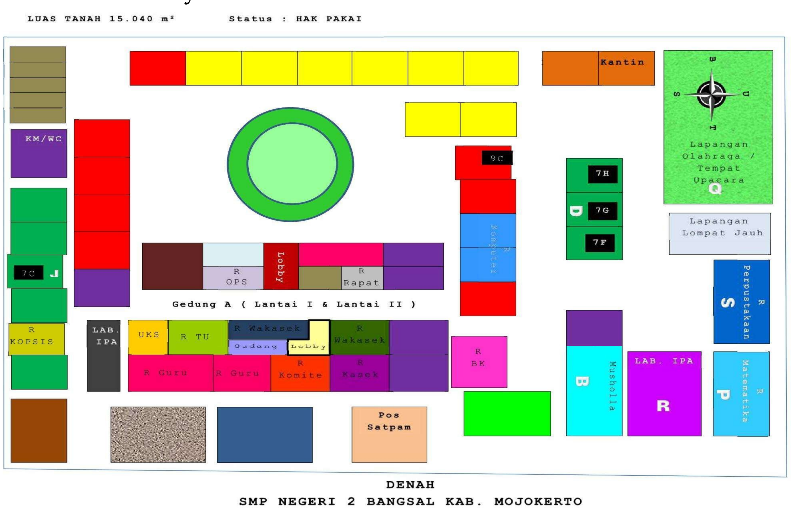

Figure 1. *floor plan of SMP Negeri 2 Bangsal*

SMP Negeri 2 Bangsal consists of several buildings, including Grade 7–9 Classrooms (24 classrooms), a Soccer/Flag Ceremony Field, Library, Mathematics Room, Northern Science Laboratory, Long Jump Field, Northern Canteen, Prayer Room (Musholla), Counseling Room (BK), Generator Room, Greenhouse, Computer Room, Security Post, Volleyball Court, Teacher/Staff Parking Area, Student Parking Area, Teacher Toilets, Student Toilets, Principal's Office, Vice Principals' Offices, Storage Room, Teachers' Room, Administration Office, Health Unit (UKS), Lobby, Meeting Room, Operations Room, Southern Science Laboratory, Student Cooperative Room (KOPSIS), Southern Canteen, and Main Garden.

Based on the data above, the scanned area was divided into six main work zones to simplify the data acquisition process. These zones are presented in the table below:

***Table 1**. Zoning-Based Spatial Layout*

Zone	Room Description
1	Teacher Parking Area, Volleyball Court, Security Post
2	Southern Science Laboratory, Classrooms 7A–7C, Student Cooperative Room, Student Toilets, Classrooms 9D–9G
3	Main Building, Counseling Room (BK), Computer Room, Generator Room, Teachers' Room, Classrooms 8G–8H, Classroom 9A
4	Main Garden
5	Student Toilets, Southern Canteen, Classrooms 8A–8F, Classrooms 9H and 9B
6	Classrooms 7F–7G, Student Toilets, Prayer Room (Musholla), Library, Mathematics Room, Soccer/Flag Ceremony Field, Northern Science Laboratory, Long Jump Field

This zoning was established to optimize the scanning process and facilitate data processing during the 3D model reconstruction stage.

Before performing a full scan of the entire SMP Negeri 2 Bangsal area, a small-scale trial was conducted to ensure that the device, application, and dynamic scanning method functioned optimally under actual field conditions.

The trial was carried out in a portion of the school garden area. This location was chosen due to its moderate complexity, sufficient lighting, and good accessibility.

The results of the trial indicated that:

1. The LiDAR sensor on the iPhone 15 Pro Max was able to capture data with adequate detail at a distance of 1–3 meters.
2. Areas with reflective surfaces produced point clouds with higher noise levels.
3. Movements that were too fast resulted in geometric distortions in the model.

Subsequently, the scanning process was carried out in the six previously defined zones.

During scanning, movement was maintained at a constant and steady pace with moderate speed, avoiding sudden or overly rapid motion that could result in blurry or incomplete point cloud data.

The researcher walked around the primary objects and ensured that all wall and floor surfaces were fully captured in the dataset.

***Figure 2**. Scanning Area*

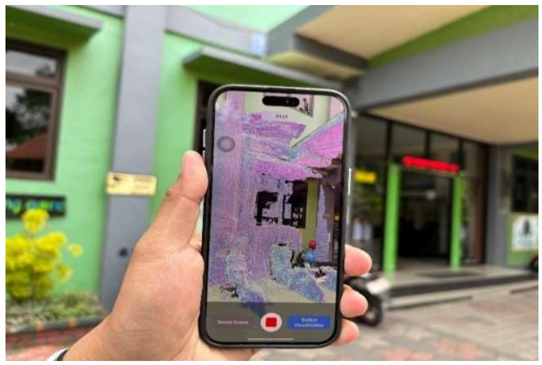

***Figure 3.** View Of Scanning*

Scanning was conducted under optimal lighting conditions. For outdoor areas, the process was carried out during clear weather to avoid harsh shadows and distortion. Meanwhile, in indoor areas, additional lighting was used when necessary. After each zone was scanned, the data was immediately saved in the Polycam application and exported in .obj or .ply format.

These steps were repeated consistently for each zone, with an average scanning time of 15 to 25 minutes per zone.

B. Planning

Based on the results obtained from the data collection and analysis phase—which included the existing floor plan and room names, observations of scanning zones and division of work areas, a small-scale trial to ensure the readiness of devices and methods, as well as field data collection using a LiDAR sensor—the process can now proceed to the development stage.

In this development stage, the point cloud data obtained from the scanning will be processed into an accurate three-dimensional (3D) model and arranged into a two-dimensional (2D) floor plan. This serves as an informative spatial representation that can be used for documentation, visualization, and further analysis.

C. Development Result

As a result of the scanning process for each zone using the LiDAR sensor on the iPhone 15 Pro Max, the output obtained was a raw point cloud, representing a three-dimensional spatial visualization of the school buildings and surrounding environment. This visualization was displayed in the CloudCompare application after importing the .obj file.

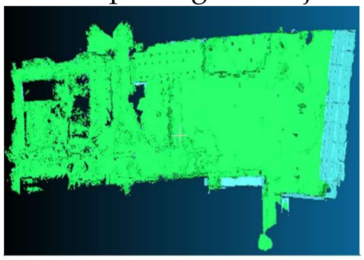

Figure 4. *Zone 1*

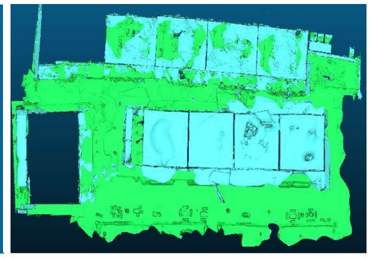

Figure 5. *Zone 2*

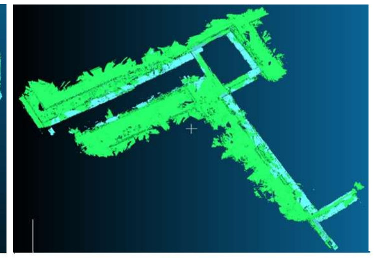

Figure 6. *Zone 3*

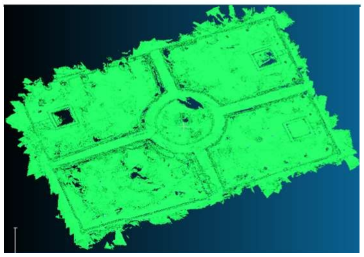

Figure 7. *Zone 4*

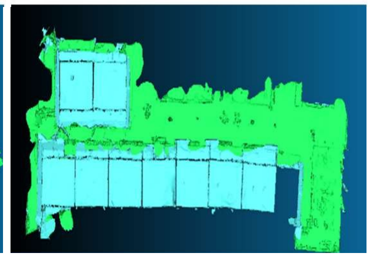

Figure 8 . *Zone 5*

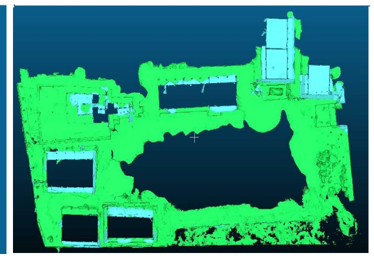

Figure 9. *Zone 6*

The next step is the georeferencing of the point cloud data. This process was carried out by selecting four control points—A0, A1, A2, and A3—which were linked to geocentric coordinate data R0, R1, R2, and R3. The choice of four control points, one on each side, follows the requirements defined in LiDAR data processing software, where a minimum of three control points is necessary to perform the georeferencing process.

After all six scanning zones were merged into a single complete unit, the final result is shown in the figure below.

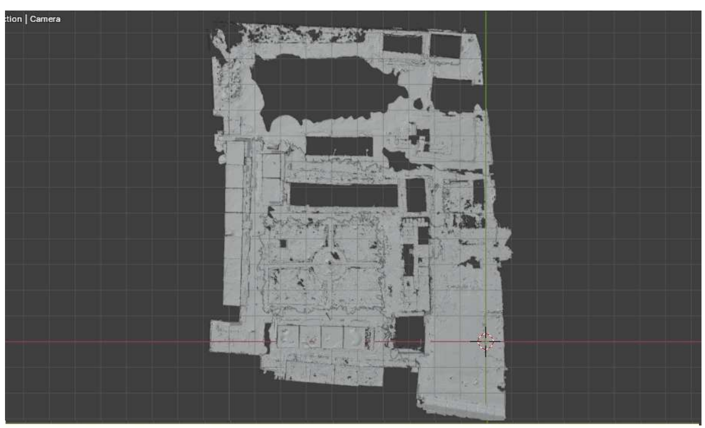

Figure 10. *The Six Zones Have Been Combined*

This process began by merging all the scanned data from each zone to form a complete model representing the entire building. The merging was carried out using software that supports 3D formats, and the resulting file was exported in .dae (Digital Asset Exchange) format as an initial step for converting the data into a format readable by AutoCAD.

Once the export was completed, the .dae file was converted into a .dxf (Drawing Exchange Format) file, since AutoCAD does not directly support .dae files. In AutoCAD, the drawing process was performed manually by tracing the shapes generated from the 3D scan. Each line and surface was redrawn using AutoCAD commands such as line, polyline, offset, and trim. This was done carefully to ensure that the dimensions and proportions of the spaces remained accurate to the actual conditions.

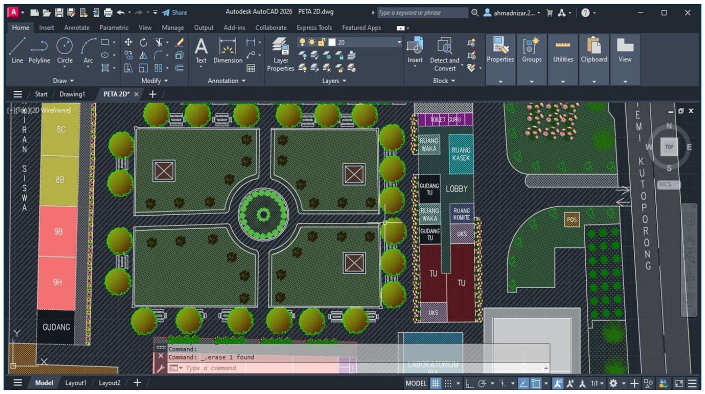

Figure 11. *Draw In The Autocad*

After all building elements were drawn, the next step was to add annotations or labels to the map. These annotations included room names, a north arrow, standard architectural symbols, a legend, the year the map was created, an inset map, data sources, and a map scale. The purpose of adding this information was to enhance the readability of the map and to make it easier for end users to interpret, particularly for documentation purposes.

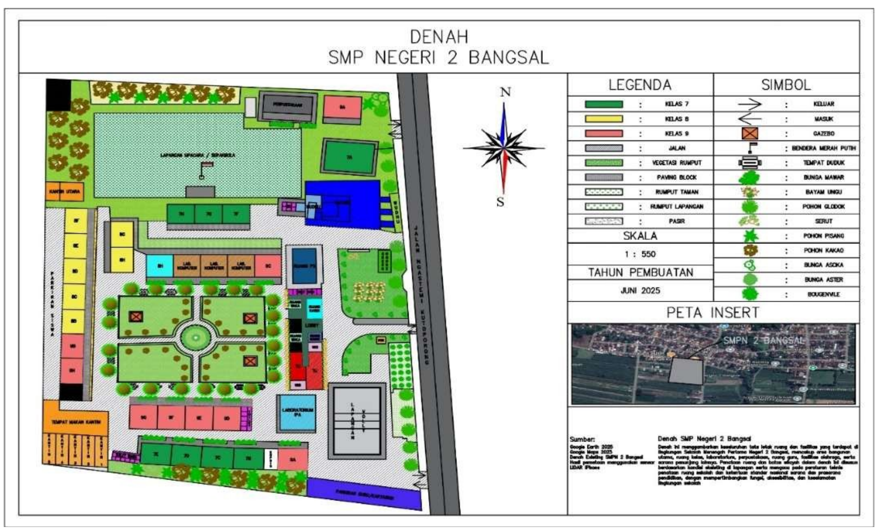

Figure 12. *Final Result Of The SMP Negeri 2 Bangsal Floor Plan (Digital Map)*

With the completion of the 2D floor plan map, the scanned data can be easily analyzed and used as one of the requirements for the Adiwiyata School Program. This stage also serves as a bridge between the data acquisition results and the final presentation process in a visual format that is easy to understand.

CONCLUSION

This study demonstrates that 3D mapping using the LiDAR sensor on the iPhone 15 Pro Max is capable of producing accurate, efficient, and informative data for school building mapping needs. Through dynamic scanning across six zones at SMP Negeri 2 Bangsal, a complete 2D map was generated from point cloud processing using CloudCompare and AutoCAD. The RMSE values for each zone indicated high accuracy, ranging from 0.025778 m to 0.1525004 m, suggesting that the data is reliable as a spatial reference for the school.

The resulting map supports the Adiwiyata Program by providing spatial information for managing green open spaces, evacuation routes, and the structured arrangement of school facilities. Mobile LiDAR technology has proven to be a practical and affordable solution, especially for schools with limited access to conventional surveying tools. Therefore, the use of LiDAR in 3D mapping is a strategic step toward improving the efficiency and sustainability of school infrastructure management.

REFERENCES

Askar, C., & Sternberg, H. (2023). Use of Smartphone Lidar Technology for Low-Cost 3D Building Documentation with iPhone 13 Pro: A Comparative Analysis of Mobile Scanning Applications. *Geomatics*. https://doi.org/10.3390/geomatics3040030

Aziz, K. M. A., Daoud, A. O., Singh, A., & Alhusban, M. (2025). Integrating digital mapping technologies in urban development: Advancing sustainable and resilient infrastructure for SDG 9 achievement – a systematic review. *Alexandria Engineering Journal*. https://doi.org/10.1016/j.aej.2024.12.078

Dhruwa, L., & Garg, P. K. (2023). POSITIONAL ACCURACY ASSESSMENT OF FEATURES USING LIDAR POINT CLOUD. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLVIII-M–3*, 77–80. https://doi.org/10.5194/isprs-archives-XLVIII-M-3-2023-77-2023

Kang, C. L., Cheng, Y., Wang, F., Zong, M. M., Luo, J., & Lei, J. Y. (2020). THE APPLICATION OF UAV OBLIQUE PHOTOGRAMMETRY IN SMART TOURISM: A CASE STUDY OF LONGJI TERRACED SCENIC SPOT IN GUANGXI PROVINCE. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-3/W10*, 575–580. https://doi.org/10.5194/isprs-archives-XLII-3-W10-575-2020

Kottner, S., Thali, M., & Gascho, D. (2023). Using the iPhone's LiDAR technology to capture 3D forensic data at crime and crash scenes. *Forensic Imaging*. https://doi.org/10.1016/j.fri.2023.200535

Luetzenburg, G., Kroon, A., Kjeldsen, K., Splinter, K., & Bjørk, A. (2024). High-resolution topographic surveying and change detection with the iPhone LiDAR. *Nature Protocols*. https://doi.org/10.1038/s41596-024-01024-9

Mehendale, N., & Neoge, S. (2020). Review on Lidar Technology. *Corporate Governance Educator: Courses*. https://doi.org/10.2139/ssrn.3604309

Patel, U. R., Ghaffarianhoseini, A., Ghaffarianhoseini, A., & Burgess, A. (2024). Digital Twin Technology for sustainable urban development: A review of its potential impact on SDG 11 in New Zealand. *Cities*.

https://doi.org/10.1016/j.cities.2024.105484

Pelita, A. C., & Widodo, H. (2020). Evaluasi Program Sekolah Adiwiyata Di Sekolah. *Sekolah Dasar: Kajian Teori Dan Praktik Pendidikan*, *29*(2), 145–157. http://journal2.um.ac.id/index.php/sd/

Rahmawati, D. L., & Arifin, Z. (2021). The Facilities and Infrastructure Management of Adiwiyata School at MTs Negeri Sleman. *Proceedings of the 5th International Conference on Learning Innovation and Quality Education*. https://doi.org/10.1145/3516875.3516932

Skuppin, N., Hoffmann, E., Shi, Y., & Zhu, X. X. (2022). Building Type Classification with Incomplete Labels. *IGARSS 2022 - 2022 IEEE International Geoscience and Remote Sensing Symposium*, 5844–5847. https://doi.org/10.1109/IGARSS46834.2022.9884076

Suzuki, T., Shiozawa, S., Yamaba, A., & Amano, Y. (2021). Forest Data Collection by UAV Lidar-Based 3D Mapping: Segmentation of Individual Tree Information from 3D Point Clouds. *International Journal of Automation Technology*, *15*(3), 313–323. https://doi.org/10.20965/ijat.2021.p0313

Wei, Q., Nurmemet, I., Gao, M., & Xie, B. (2022). Inversion of Soil Salinity Using Multisource Remote Sensing Data and Particle Swarm Machine Learning Models in Keriya Oasis, Northwestern China. *Remote Sensing*, *14*(3). https://doi.org/10.3390/rs14030512

Yuda, R. S. (2022). Pemetaan Cepat 3D untuk Pemodelan Bangunan Bersejarah Menggunakan Sensor LiDAR iPad Pro dan Implementasi Teknologi Augmented Reality dalam Visualisasi 3D Berbasis iOS Mobile (Studi Kasus: Candi Sumberawan, Kabupaten Malang). *ITN MALANG*.

Zimmer, W., Birkner, J., Brucker, M., Tung Nguyen, H., Petrovski, S., Wang, B., & Knoll, A. C. (2023). InfraDet3D: Multi-Modal 3D Object Detection based on Roadside Infrastructure Camera and LiDAR Sensors. *2023 IEEE Intelligent Vehicles Symposium (IV)*, 1–8. https://doi.org/10.1109/IV55152.2023.10186723