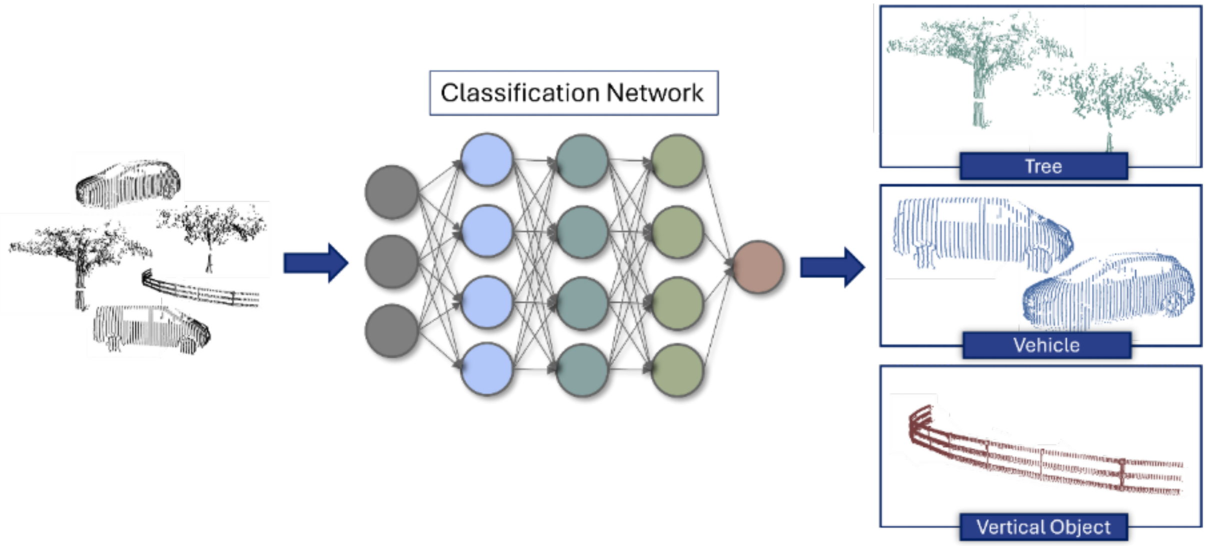
Advancing Point Cloud Classification Using Real-World Urban Data



Figur 1: Deep learning network for point cloud classification. The network assigns each input object to one of several predefined classes.

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SUMMARY

3D point cloud data is essential in modern technology. Developing accurate methods for extracting meaningful information from raw data has become important for advancing applications in autonomous systems, robotics, and smart city infrastructure.

INTRODUCTION

Point cloud data, which is a set of unordered points in a 3D coordinate system, provide an accurate representation of real-world environments. While point clouds contain rich geometry information, the irregular nature and large data volume make point cloud classification a challenging and interesting research domain (Zhang et al., 2023).

Point cloud data are acquired using Light Detection and Ranging (LiDAR) technology to generate precise 3D representations of the environment. Mobile Laser Scanning (MLS) is a surveying technology where the laser scanner is mounted on a moving platform, allowing for detailed 3D scanning of urban areas (Wang et al., 2019).

The presented research aims to contribute to the existing work on point cloud classification by introducing a new deep learning module to make deep learning networks more accurate. The proposed module can be integrated into existing networks for point cloud classification to improve performance.

METHOD

Point cloud classification aims to classify objects in the point cloud into predefined classes. Deep learning has achieved great success in point cloud classification, enabling networks to learn how to identify complex patterns and relations from labelled training data. When a point cloud is fed into the network, it is processed through multiple layers, transforming the raw data into feature maps, which are internal representations highlighting the characteristics of the input.

However, as the network gets deeper, the number of extracted features grows and becomes more computationally expensive to process. To address this, deep learning networks use a technique referred to as pooling, which reduces the dimensions of the feature map by summarising the information and only retaining the most relevant features. Traditional pooling methods are simple and efficient and work well in many cases. However, they may discard relevant information. Therefore, this research introduces a new pooling module, which can enable the network to make more accurate predictions.

RESULT

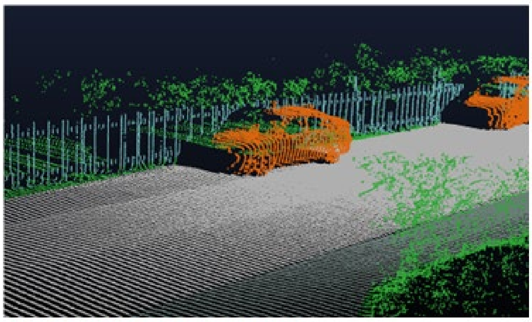

Fig 2. Example of MLS data of Trondheim.

A dataset consisting of MLS point cloud data collected by Trondheim Municipality is used to evaluate the performance of the proposed module. This data captures the road environment across Trondheim. Figure 2 shows an example of the MLS data where the objects are coloured for illustration purposes. Seven common objects in the road environment are classified: road surfaces, pavements, trees, pole-like objects (traffic signs, lamp posts, etc.), vehicles, vertical objects (buildings and fences), and vegetation.

The proposed module is implemented into several deep learning models for point cloud classification. These models are then trained using the MLS point cloud data of Trondheim. Each model is trained both with and without the proposed pooling module to compare their performance. The results revealed that all tested models achieved an improved accuracy with the new pooling module.

CONCLUSION

As 3D data becomes more important in technologies for autonomous vehicles and smart cities, it is important to develop accurate methods for extracting valuable information from raw data. The proposed module improves how deep learning networks summarise and focus on the most relevant features, leading to more accurate classification results. When evaluated on real-world data from Trondheim, this module enhanced performance across all tested deep learning models.

Leveraging data from Trondheim to develop and train deep learning models enables the development of more reliable digital twins of the city's infrastructure. Further, these models can support planning of road maintenance as well as improving mobility planning.

Further research may involve evaluating how the module performs on larger-scale datasets, and its ability to generalise across different urban environments beyond Trondheim.

Such evaluations can be used to better assess its robustness in different real-world conditions.

REFERENCES

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Wang, Y., Chen, Q., Zhu, Q., Liu, L., Li, C., & Zheng, D. (2019). A survey of mobile laser scanning applications and key techniques over urban areas. *Remote Sensing, 11*(13), 1540. https://doi.org/10.3390/rs11131540