JPEG PLENO Point Cloud Coding

Stuart Perry (University of Technology Sydney, Australia)

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Rapid Rise of Point Cloud Data

- Point Cloud acquisition and processing is becoming crucial to society

- Consumption of point clouds by machines and humans is growing exponentially

- Standards that support human and machine use are crucial.

"Unlimited 3D Point Cloud Search Cited as Game Changing", May 2020
https://lidarnews.com/articles/unlimited-3d-point-cloud-search-cited-as-game-changing/

"ByteBridge Launches World's First Mobile 3D Point Cloud Data Labeling Service", June 2021
https://medium.com/nerd-for-tech/bytebridge-launches-worlds-first-mobile-3d-point-cloud-data-labeling-service-cf87a4ed2067
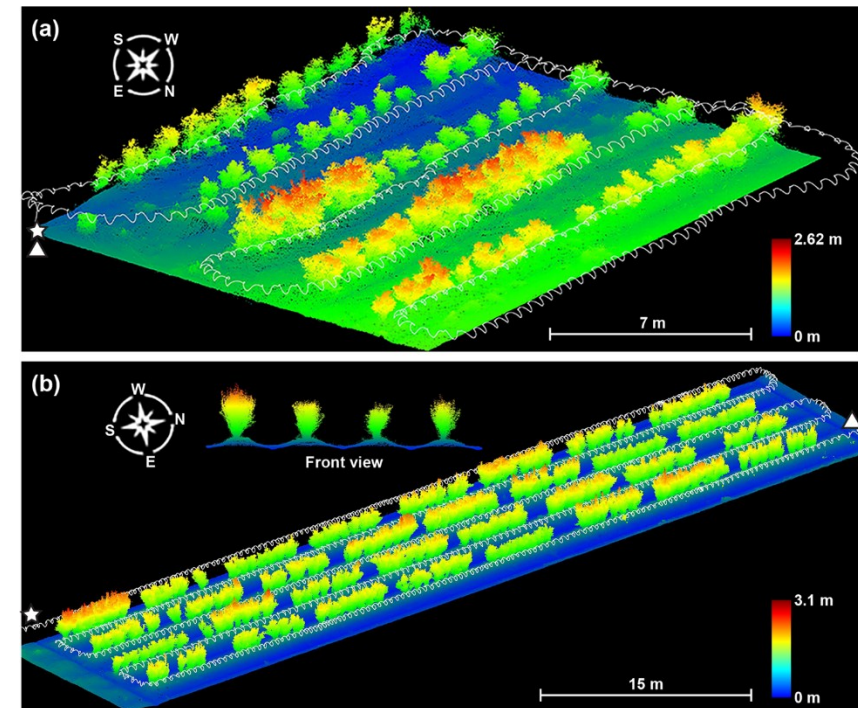
Jiang, Y., Li, C., Takeda, F. *et al.* 3D point cloud data to quantitatively characterize size and shape of shrub crops. *Hortic Res* **6,** 43 (2019). https://doi.org/10.1038/s41438-019-0123-9

Use Cases and Requirements

Key Use Cases:

- **Wide-area survey/3D mapping**

- **Autonomous driving**

- **Manufacturing – traditional and additive systems**

- **On-line shopping**

- **Fault and defect detection in manufacturing and construction**

- **Cultural Heritage**

The image is a LIDAR scan of Buckingham Palace, UK and is courtesy of Environmental Agency (https://www.flickr.com/photos/environment-agency/27489358013)
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https://www.i-micronews.com/how-lidar-is-getting-ready-for-the-automotive-mass-market-an-interview-with-velodyne/ April 2019

Use Cases and Requirements

Key Requirements:

- **3D Metrology – Preservation of relative point positions**
- **3D Processing:**
  - **Visual Enhancement**
  - **Super Resolution**
- **Computer Vision:**
  - **Object Detection**
  - **Object Classification**
- **Scalability of Geometry and Attributes**
  - **Different degrees of precision, resolution and range**
- **Random Access – Selective decoding of a portion of the point cloud independently of the rest**
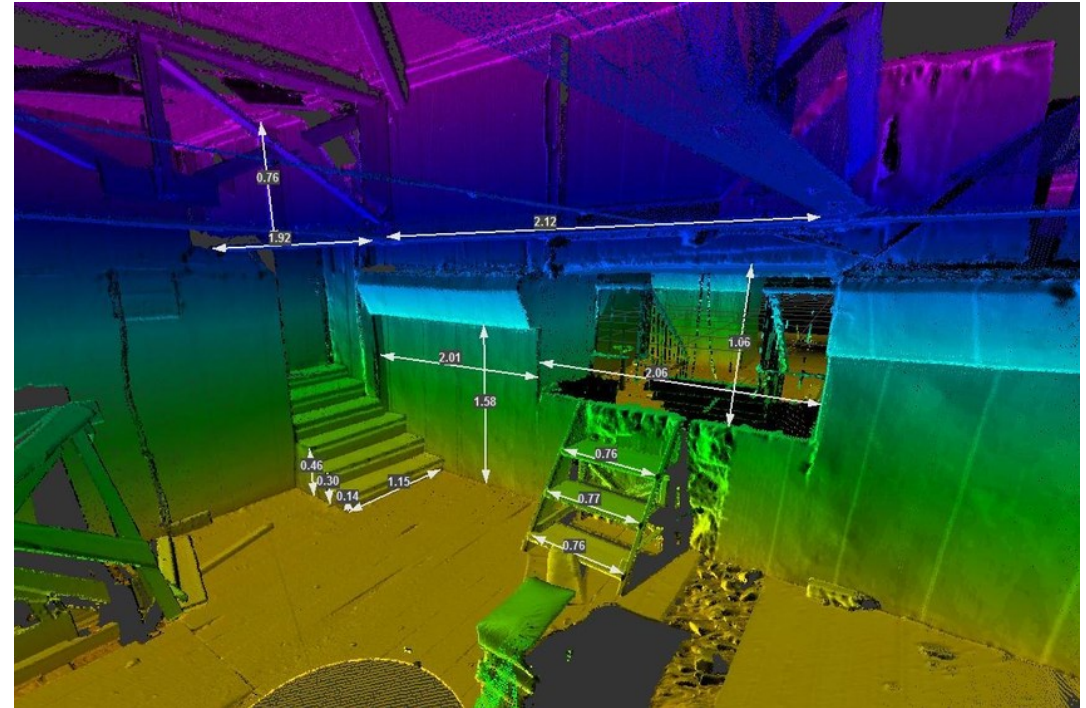
Chapter "Positioning and Applications" in National Report for the IAG of the IUGG 2011–2014, June 2015, 10.2205/2015IUGG-RU-IAG

Scope of the Activity

The scope of the JPEG Pleno Point Cloud activity is the creation of a learning-based coding standard for point clouds and associated attributes, offering **a single-stream, compact compressed domain representation, supporting advanced flexible data access functionalities**. This standard targets **both interactive human visualization**, with competitive compression efficiency compared to state of the art point cloud coding solutions in common use, **and effective performance for 3D processing and machine-related computer vision tasks**, and has the goal of supporting a **royalty-free baseline**.

Stages of the Activity

Stage 1: A learning-based coding standard addressing human visualization and **decompressed/reconstructed domain 3D processing and computer vision tasks**;

Stage 2: A learning-based coding standard additionally supporting **compressed domain 3D processing** such as visual enhancement and super-resolution and;

Stage 3: A learning-based coding standard additionally supporting **compressed domain computer vision** tasks such as classification, recognition and segmentation.
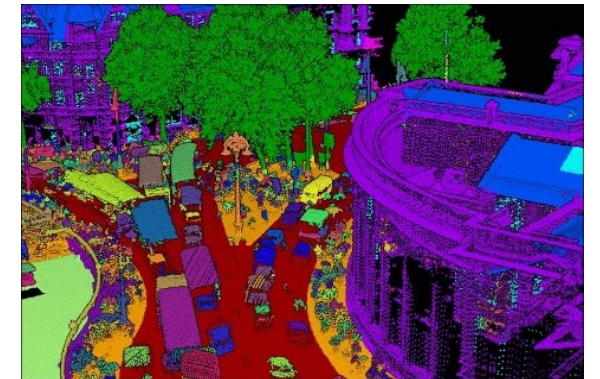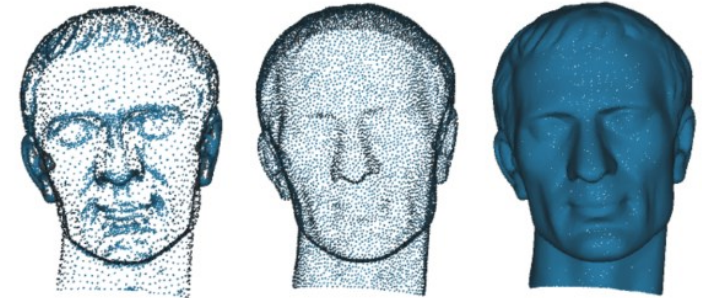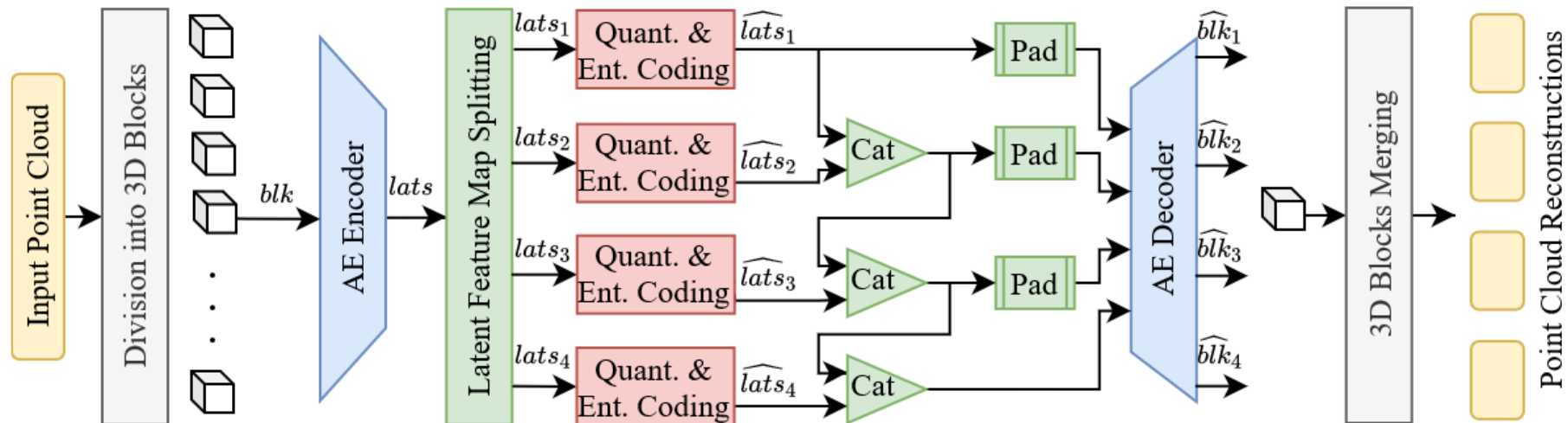
Learning-based Point Cloud Coding

- In May 2020, JPEG released a **Call for Evidence on JPEG Pleno Point Cloud Coding**
  - Focused on scalability and random access

- A submission to the call was a learning-based point cloud codec displaying both random access and scalability functionality:
  - wg1m90019-REQ-IT_IST_IPLeiria_Response_to_Call_for_Evidence_on_JPEG_Pleno_Point_Cloud_Coding.pdf

Learning-based Point Cloud Coding

- Most solutions in this area use an autoencoder framework
  - An encoder module reduces the dimensionality of the point cloud into a latent domain representation.
  - The latent domain representation is quantised and coded.
  - A decoder module reconstructs the point cloud.

Learning-based Point Cloud Coding

- Learning-based Point Cloud Coding solutions are an important emerging trend and like learning-based image coding solutions show the potential for competitive performance against existing solutions

- Learning-based Point Cloud computer vision applications are also in rapid growth

- **The frameworks of solutions to the two fields have much in common indicating the potential for combining compression and computer vision in new, powerful frameworks.**
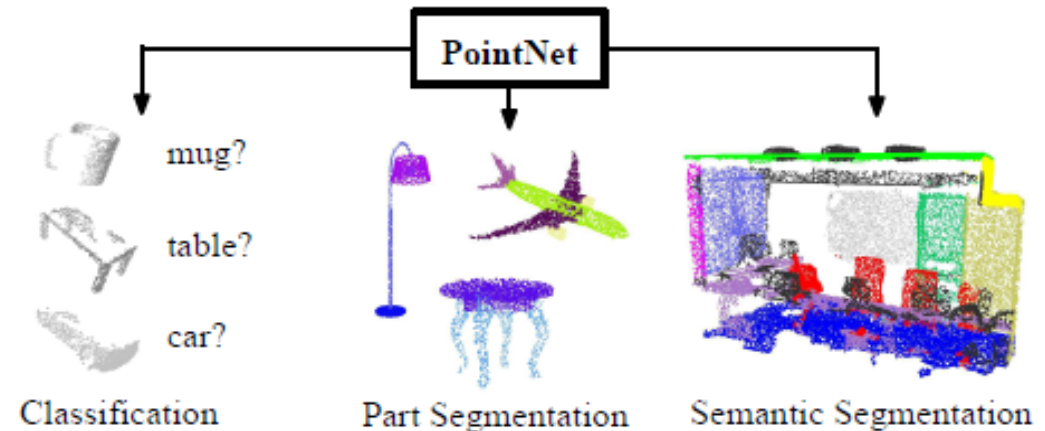

Figure 1. **Applications of PointNet.** We propose a novel deep net architecture that consumes raw point cloud (set of points) without voxelization or rendering. It is a unified architecture that learns both global and local point features, providing a simple, efficient and effective approach for a number of 3D recognition tasks.

PointNet: Deep Learning on Point Sets for 3D Classification and Segmentation, CVPR 2017

Draft Call for Proposals on JPEG Pleno Point Cloud Coding

Released at end of 93rd JPEG Meeting, 22nd October 2021

This call addresses learning-based coding technologies for static point cloud content and associated attributes with emphasis on both human visualization and decompressed/reconstructed domain 3D processing and computer vision with competitive compression efficiency compared to point cloud coding standards in common use, with the goal of supporting a royalty-free baseline.

Common Training and Test Conditions

Common *Training and* Test Conditions must adapt to a learning-based paradigm to support CfP.

This includes:

- Datasets split into training and testing
  - Testing sets must be secret

- Subjective testing procedures and objective measures must adapt to rapidly evolving field.

- New objective measures such as computational efficiency need to be considered.

Timeline of Activity (Under Discussion)

93rd JPEG Meeting, Oct/2021	**Release of Draft Call for Proposals on JPEG Pleno Point Cloud Coding.**
94th JPEG Meeting, Jan/2022	**Final Call for Proposals on JPEG Pleno Point Cloud Coding.** **Release of the final version of the JPEG Pleno Point Cloud Use Cases and Requirements document.** **Release of the final version of the JPEG Pleno Point Cloud Coding Common Training and Test Conditions document.**
Mar/2022	**Deadline for registration for participation in this Call for Proposals.**
95th JPEG Meeting, Apr/2022	**Status evaluation of the Call for Proposals, review of registrations, organization of evaluation procedures and practical arrangements.**
May/2022	**Deadline for submission of responses to this Call for Proposals. JPEG begins subjective evaluation of proposals.**
96th JPEG Meeting, Jul/2022	**Presentation of proposals, together with review of subjective evaluation results from experiments performed by JPEG.** **Decision on future actions regarding point cloud coding standardization in JPEG.**
Oct/2022	**Release of Working Draft (WD) on JPEG Pleno Point Cloud Coding**
Apr/2023	**Release of Committee Draft (CD)**
Oct/2023	**Release of Draft International Standard (DIS)**
Apr/2024	**Publication of an International Standard on JPEG Pleno Point Cloud Coding**

How to participate:
JPEG Pleno Point Cloud Ad hoc Group

- Ad hoc Group on JPEG Pleno - Lightfield
- Ad hoc Group on JPEG Pleno - Holography
- **Ad hoc Group on JPEG Pleno - Point Clouds**

Email reflector: **jpeg-Pointcloud**
To subscribe to the reflector, please visit http://listregistration.jpeg.org

or in case of problems contact
lists@jpeg.org

Mandates (in General Sense):

Improve existing JPEG standards and advance still image standards to the point cloud domain

- Consult with Industry and Academia to determine use cases and requirements for static point cloud coding
- Collect a database of point clouds for testing and evaluation
- Design subjective and objective testing protocols for point cloud quality evaluation
- Solicit proposals for point cloud encoding and evaluate proposals
- Produce a standard for point cloud coding consistent with the JPEG Pleno framework

Chair: Stuart Perry (University of Technology Sydney, AU)
Co-Chair: Luis Cruz (University of Coimbra, PT)

Thank you!

To find out more:

https://jpeg.org/

Stuart.Perry@uts.edu.au