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Mechatronics Integration Projects

LiDAR Dataset Generation in Virtual Smart Factory Environment

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Contents

Research Background

- Need LiDAR datasets making 3D human detection model
- Difficulty obtaining human data in factory environment
- Create factory-like virtual environment -> LiDAR human dataset generation

Figure 1. Tesla Car Process

Research Purpose

- LiDAR Dataset Generation in Virtual Environment

Part 1 : Smart Factory Environment 3D Modeling

Part 2 : Human Pose 3D Modeling LiDAR Simulation in Virtual Environment

Part 3 : LiDAR Dataset Generation in Virtual Environment

Part 4 : Validation

Research Process

- **LiDAR Dataset Generation Flow-Chart**

3D Point Cloud
Data Acquirement

Part1 Factory 3D modeling

Part2 Human 3d modeling

Part3 Virtual Environment LiDAR Simulation

Part4 Validation

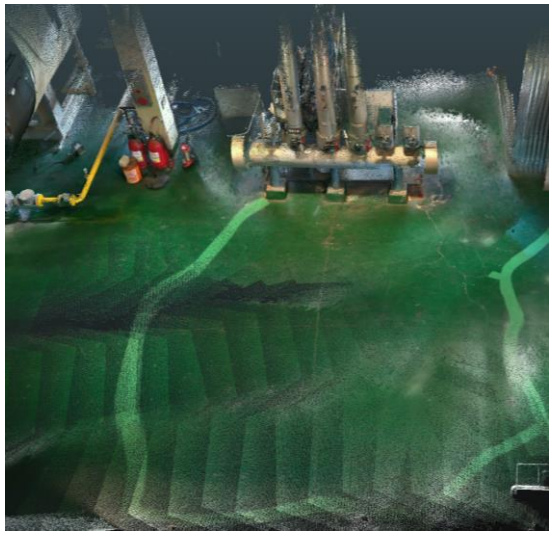


Figure 2. Point Cloud Data

Figure 3. 3D Modeling

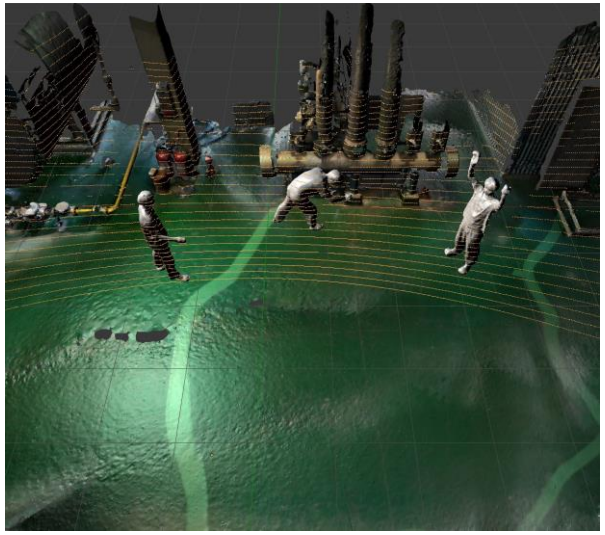


Figure 4. LiDAR Simulation

3D Point Cloud Data Acquirement

- **Place:** Handong Global University Power Plant
- **Range:** 24m (L) X 10m (D) X 8m (H)
- **Sensor:** Intel RealSense L515
- **Software:** Dot 3D [1]
- **Method :** Scan point cloud -> Accumulation data around Power Plant -> Export PLY file

Intel RealSense L515	
LiDAR Type	Depth LiDAR Camera
Depth Resolution	1024x768
FOV	70° x 55°
Range 15% Reflectivity	0.25 - 2.6m

Figure 5. Intel RealSense L515

Figure 6. Experiment Demo

● Part 1. 3D Model Rendering & Filtering

- Ball Pivoting Algorithm(BPA) that models points in the form of planes [2]

- Remove noise Laplacian Smoothing Filter [3]

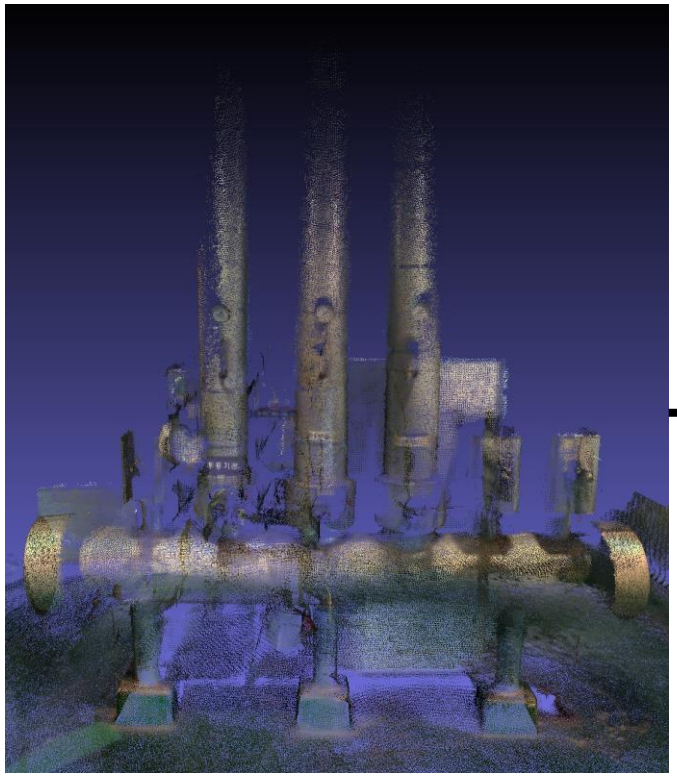


Figure 7. Point Cloud Data

Figure 8. Ball Pivoting Algorithm

Figure 9. Laplacian Smoothing Filter

● Part 1. Power Plant 3D Modeling Result

- Handong Global University Power Plant 3D Modeling

Figure 10. Power Plant Picture

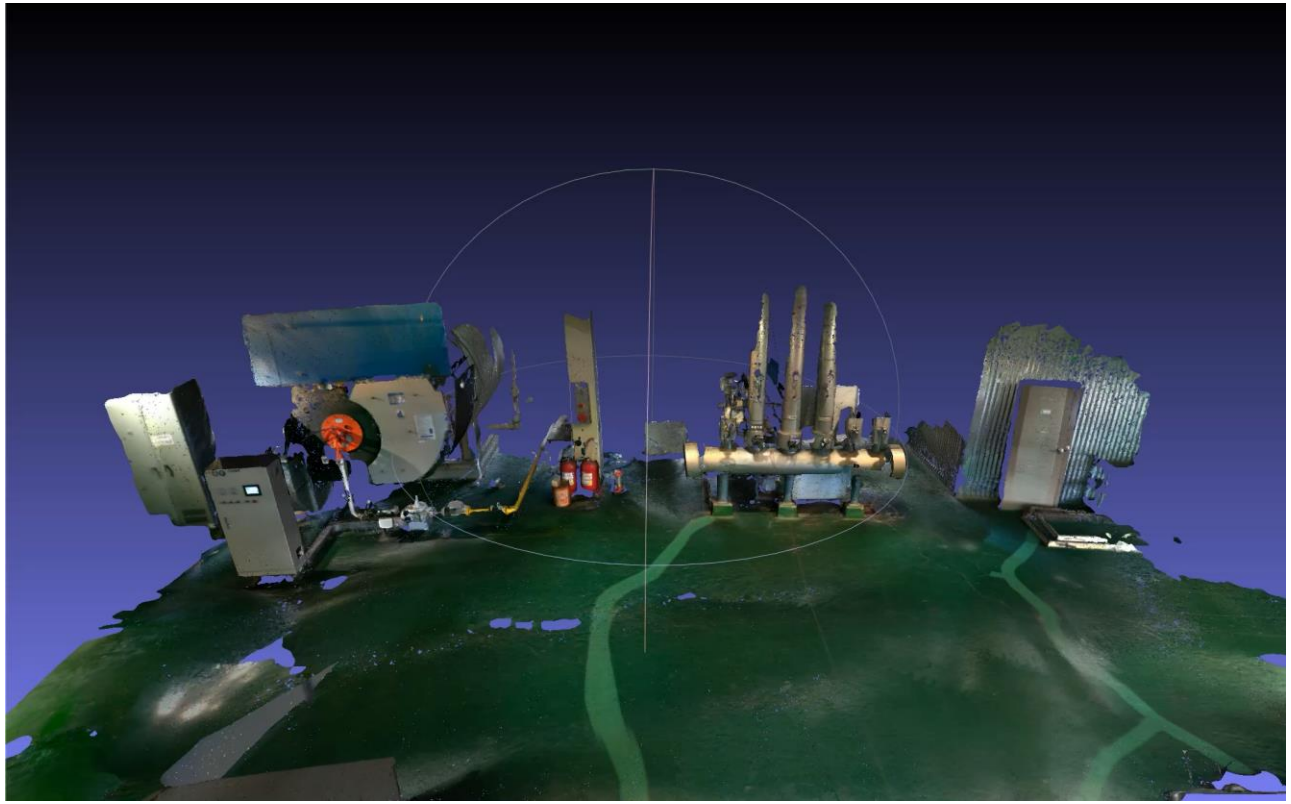


Figure 11. 3D Modeling Result for Power Plant

● Part 2. 3D Human Modeling & Filtering

- 3D Rendering to use Poisson Surface Reconstruction (points -> object) [4]
- Remove noise Laplacian Smoothing Filter [3]

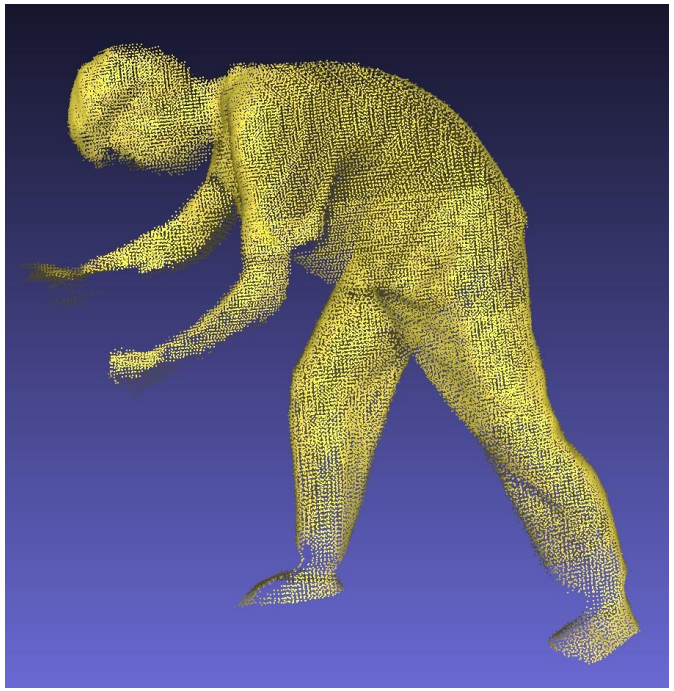


Figure 12. Point Cloud Data

Figure 13. Poisson Surface Reconstruction

Figure 14. Laplacian Smoothing Filter

● Part 2. Various Posture Human 3D Modeling

- Need to learn human detection for various posture (knee bending, shoes tie, lie, hand-up, walk)
- Human 3D Modeling to be used in LiDAR Simulation

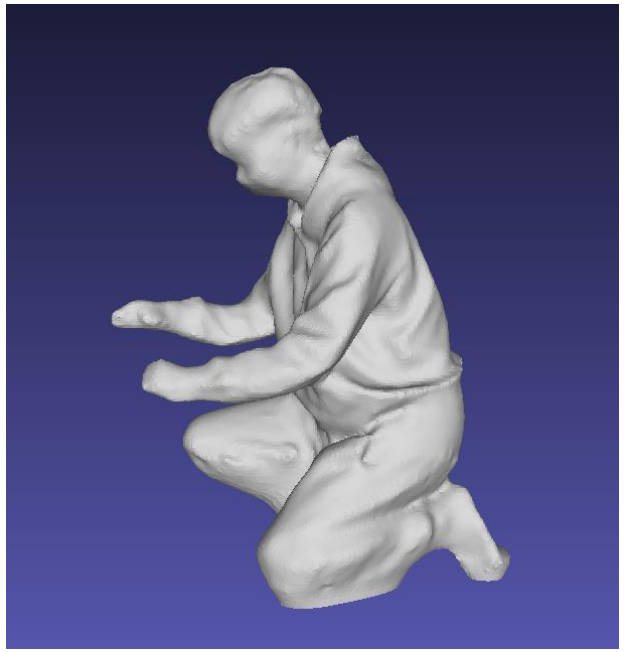


Figure 15. Knee Bending Posture

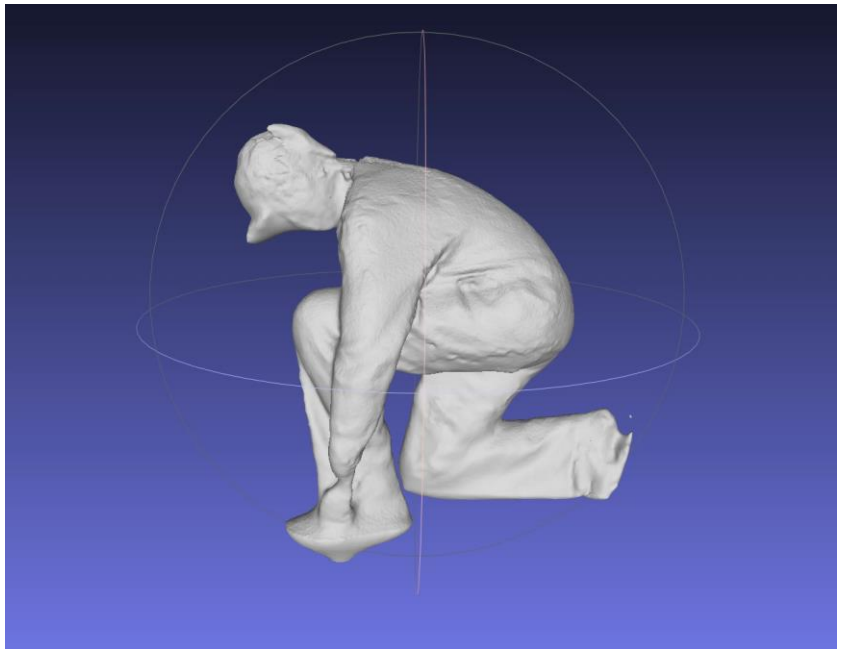


Figure 16. Shoes Tie Posture

Figure 17. Lie Posture

Part 3. Virtual Environment LiDAR Simulation

- Power Plant 3D modeling & human 3D modeling replacement
- Sensor: Set to performance like HESAI Pandar XT32 LiDAR [5]
- LiDAR dataset generation for various situations

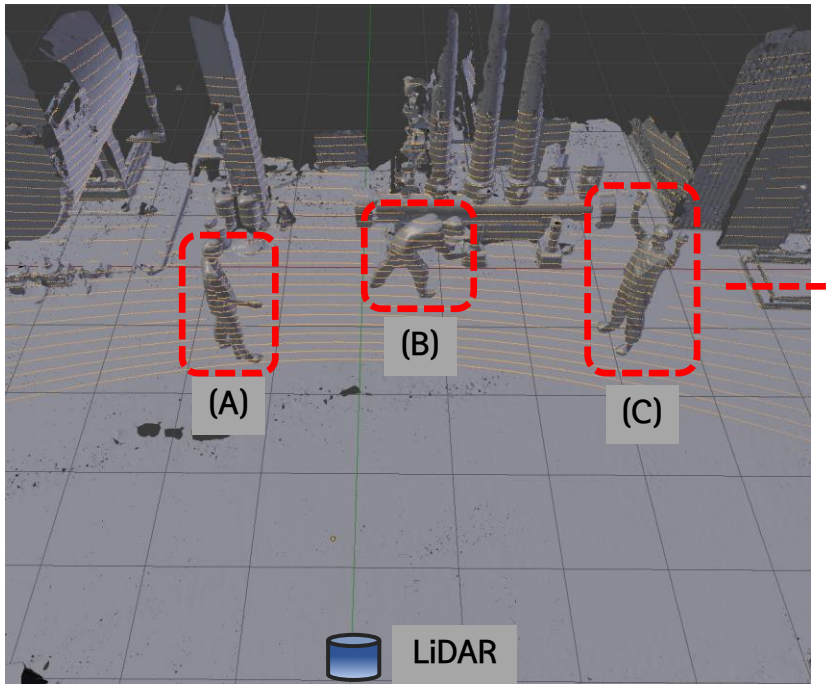
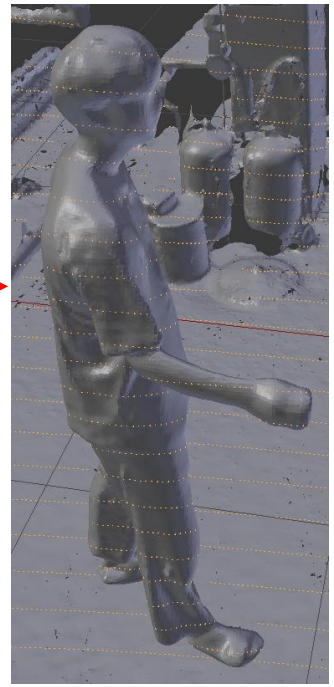
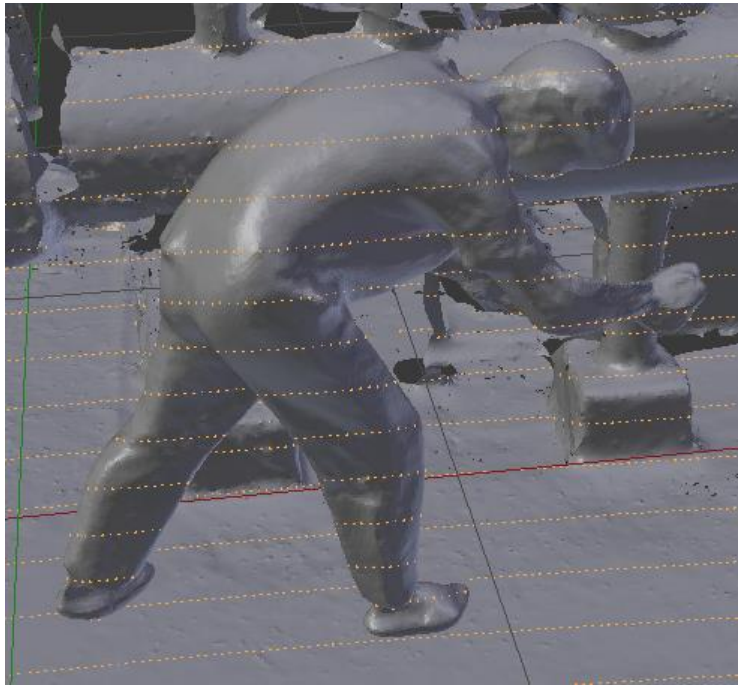


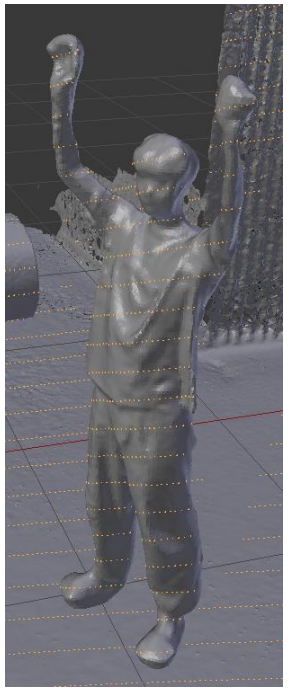
Figure 18. LiDAR Point Cloud Dataset



(A)



(B)



(C)

- **Part 4. Validation**

Model	Reference Model	Our Model
Structure	PointPillars (3D Object Detection)	
Dataset	Industry Field Data (8,998 frames)	Industry Field Data + Virtual Environment Data (8,998 + 500 frames)

Result

- Performance analysis : 85.21 AP

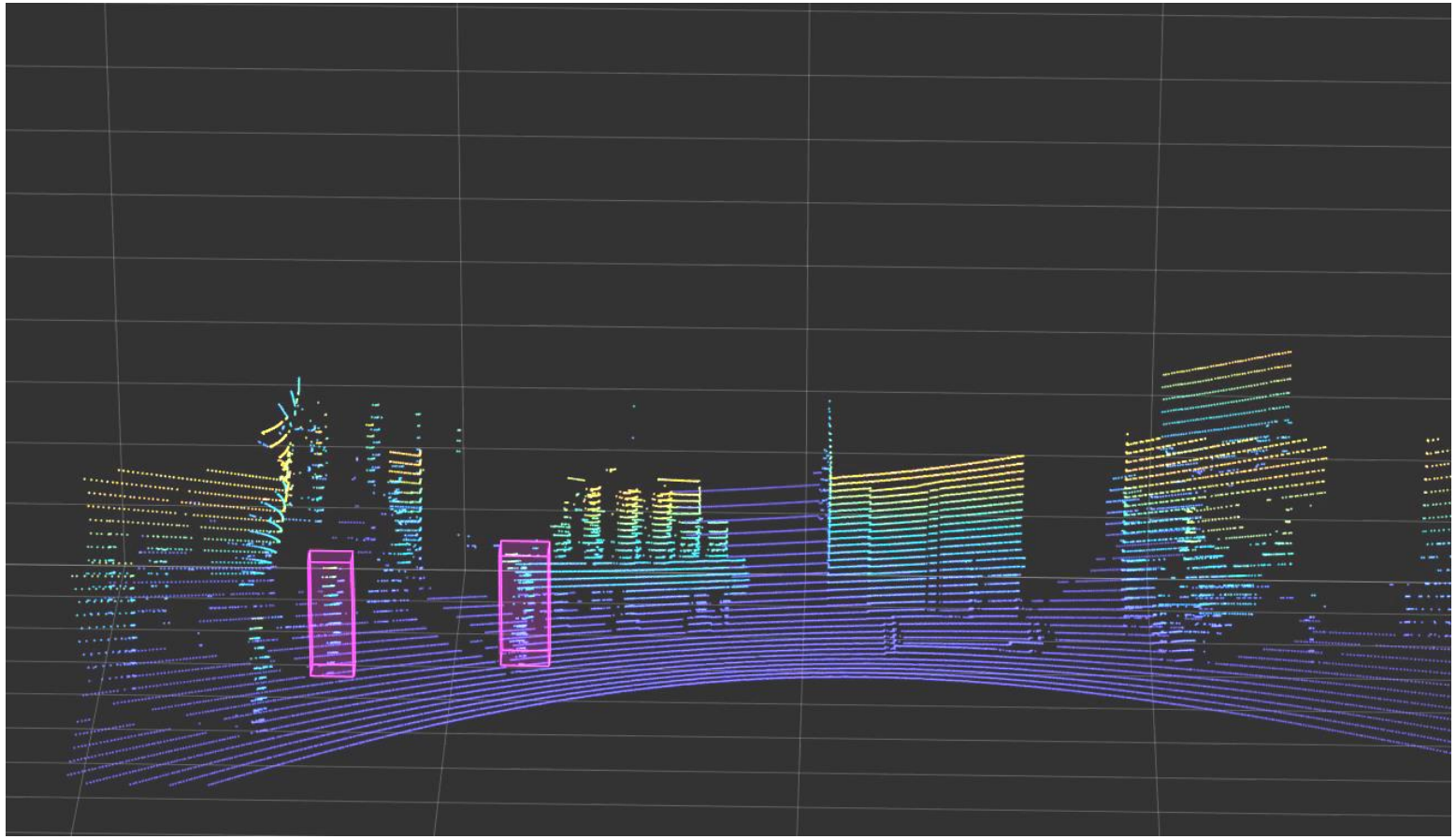


Figure 19. Human Detection Result using Improved Model

Conclusion

- **Part 1 :** Create factory-like virtual environment 3D modeling
- **Part 2 :** Create human 3D modeling in various postures
- **Part 3 :** LiDAR human dataset generation for various situations
- **Part 4 :** AP improved 80(Reference Model) to 85(Our Model)

Appendix

1. DotProduct LLC. Dot3D platform. Nov. 2, 2022. https://www.dotproduct3d.com/subscribe.html.
2. Bernardini, F., Mittleman, J., Rushmeler, H., Silva, C. and Taubin, G. The ball-pivoting algorithm for surface reconstruction. IEEE. *TVCG*. 1999.
3. Olga, S. Laplacian Mesh Processing. EUROGRAPHICS. 2005.
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5. Michael, G. Roland, K. Andreas, U. and Wolfgang, P. Blensor: Blender Sensor Simulation Toolbox. *ISVC*. 2011. https://www.blensor.org/.
6. B, Buntz. Bringing the Smart Factory Vision to Life. *IWT*. Feb. 2020. https://www.iotworldtoday.com/2020/02/20/bringing-the-smart-factory-vision-to-life.
7. Lang, A. H. Vora, S. Caesar, H. Zhou, L. Yang, J. and Beijbom, O. Pointpillars: Fast encoders for object detection from point clouds. In *CVPR*., 2019.