Deep 3D model optimisation for immersive interactive applications

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DELL'INFORMAZIONE

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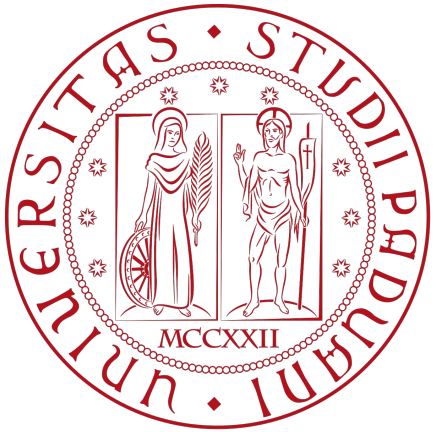

Introduction

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- Increasing popularity of immersive technology
- Many applications:
  - Entertainment
  - Education
  - Health
- Three types of immersive technologies:
  - Virtual reality (VR)
  - Mixed reality (MR)
  - Augmented reality (AR)

Virtual Reality (VR)

- Most common form of VR involves a HMD (*Head Mounted Display)* headset
- Stereoscopic vision
- 6 degrees-of-freedom movement

3D Computer Graphics

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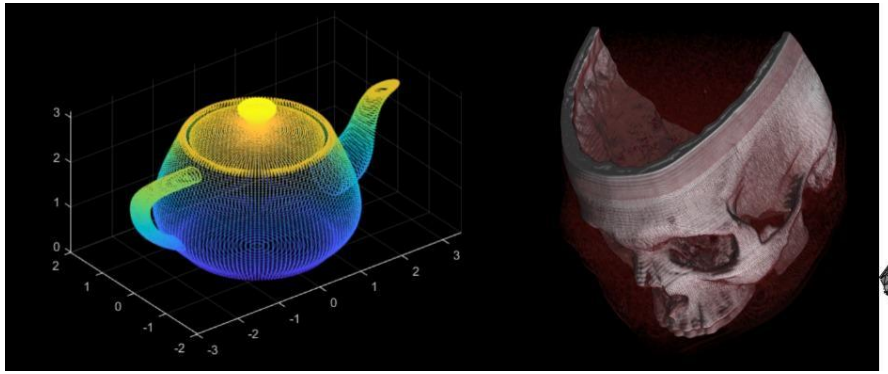
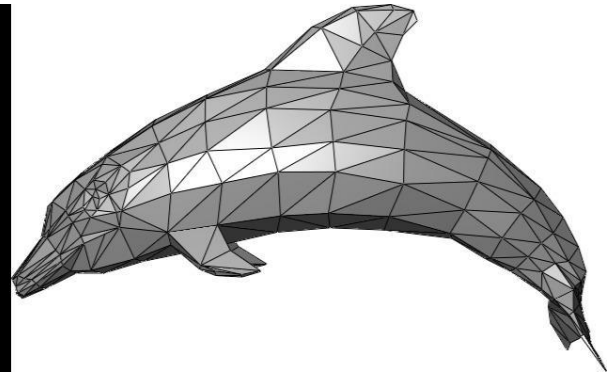
Different digital representation of 3D models:

- *Point cloud*
- *Voxel*: volumetric description
- ***Mesh*****:** object's surfaces description





Quality of Experience

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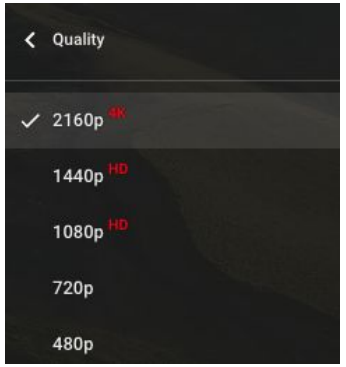
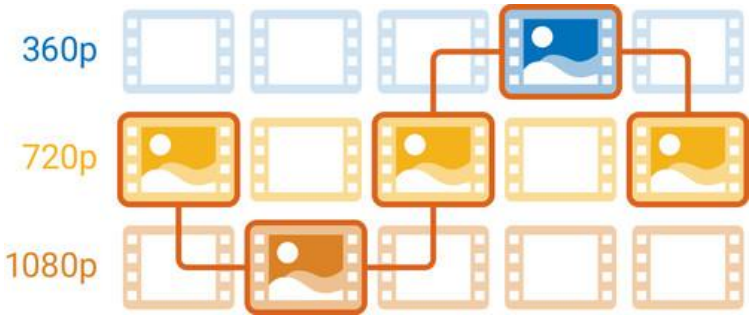
Main factors impacting QoE:

- *Frame rate* (fps)
- Latency
- Visual quality

A video streaming analogy:





Quality metrics

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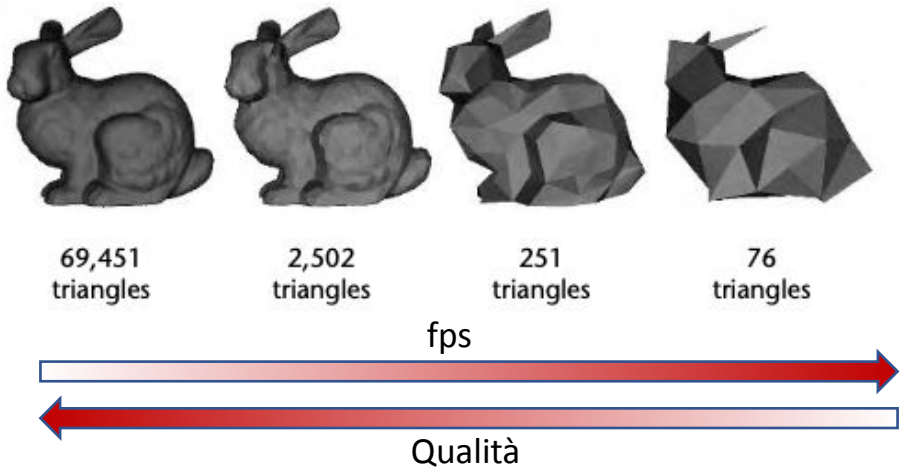
How to select the optimal level-of-detail to obtain the best compromise between frame rate and visual quality ?

→ **Define a quality metric**



SSIM *(structural similarity index measure):* measures the structural similarity between two images

$$SSIM = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

→ Evaluation of perceived quality by comparing the rendered images of original model and simplified model

Deep learning

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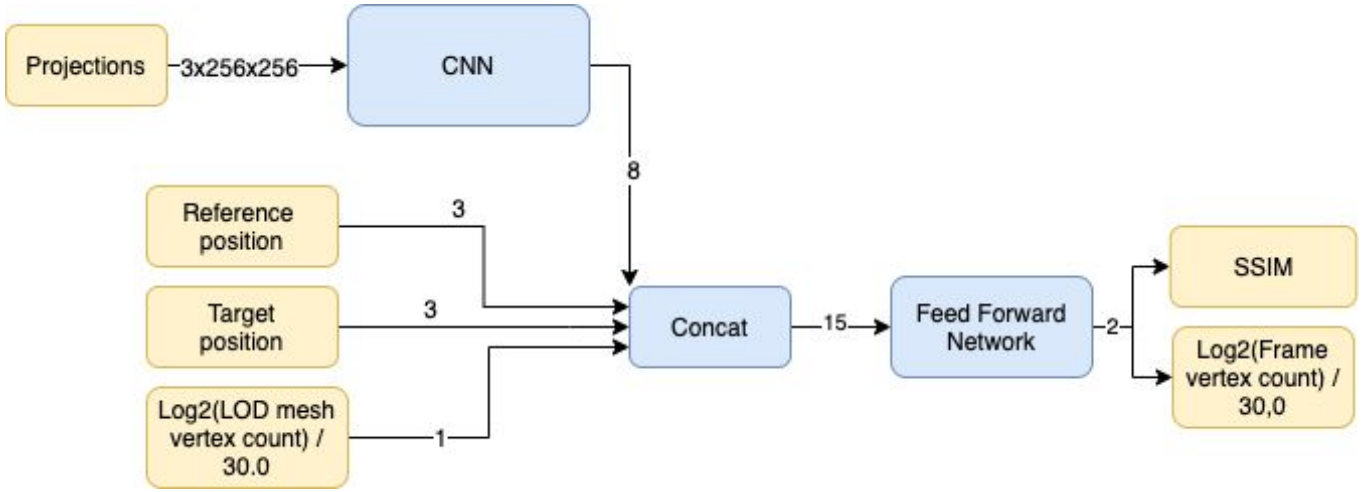
Objective: real time prediction of the perceived quality of a mesh and the frame rate

Deep Learning:
It's effectiveness in predicting data makes it suitable for predicting quality metrics



Dataset

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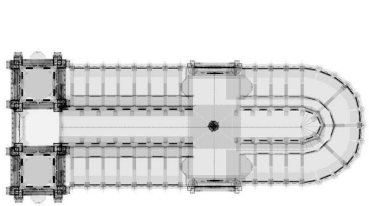
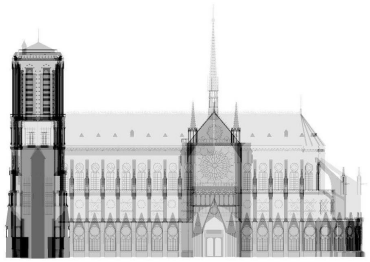
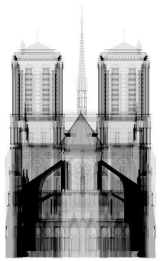
- Dataset generated using *Unity* rendering engine
- C# scripting for screenshot capturing from different point of view
- 9 3D models in 4 Level-of-Details
- 200 random viewpoints
- Orthographic surface count projections for each 3D model



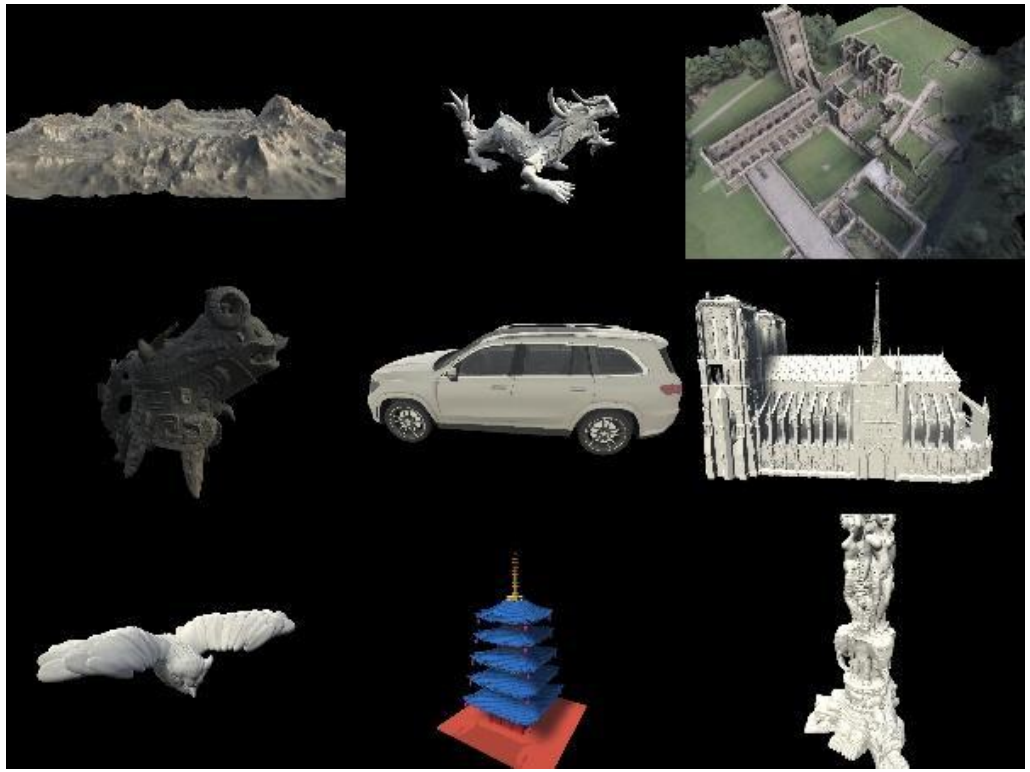
Piano Orizzontale



Piano Verticale



Piano Laterale



Data analysis

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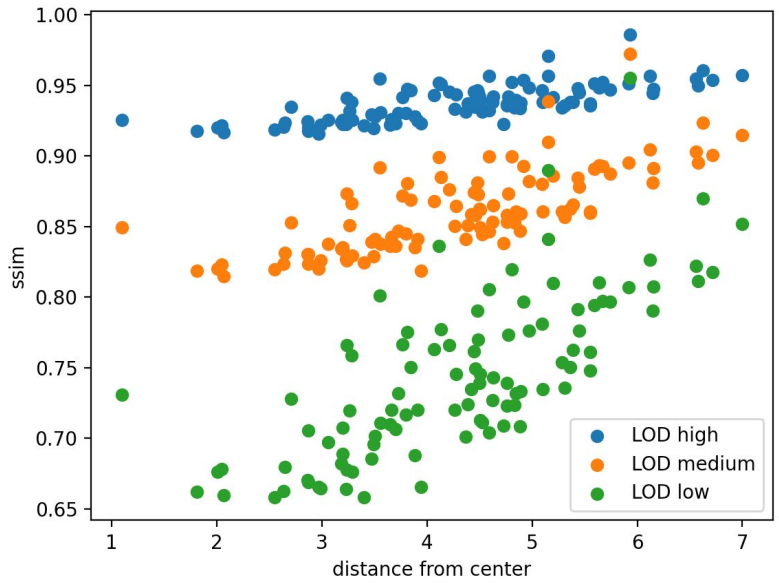
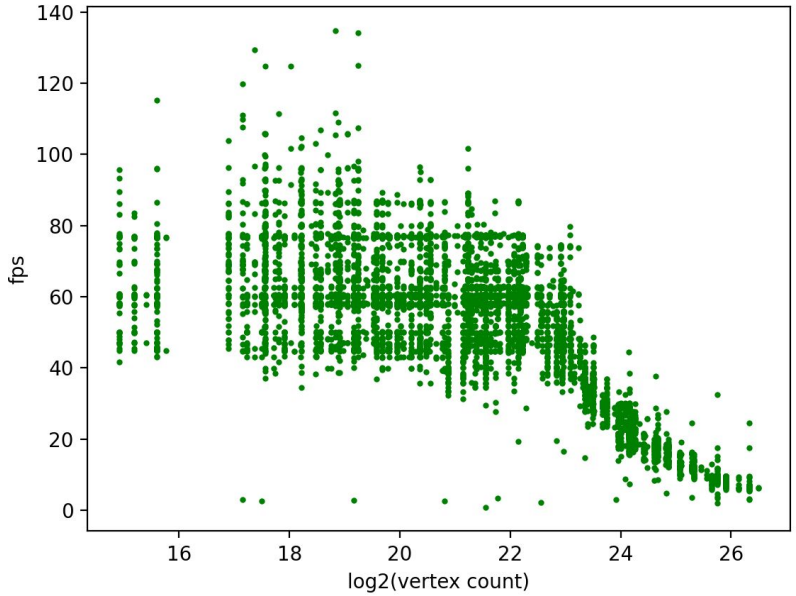
We observe an increase of the SSIM index with the distance from the object



Correlation between frame rate and the vertex count of the frame being rendered



Experimental results

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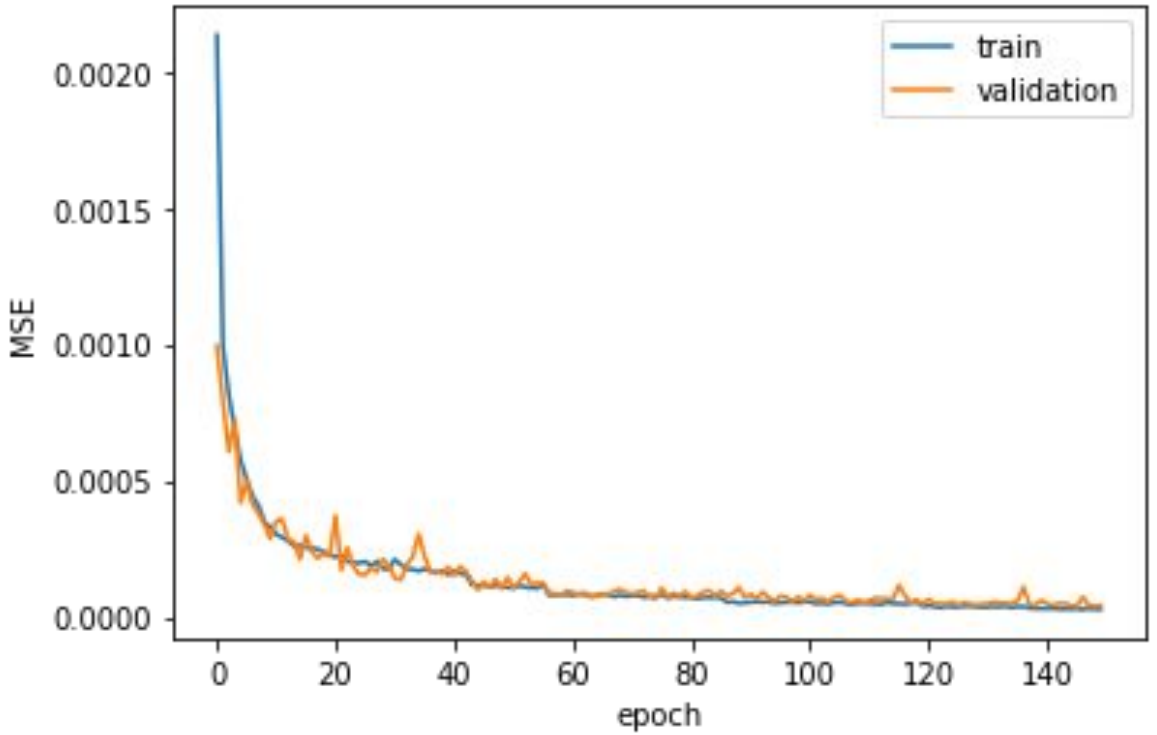
- The training curve shows an absence of overfitting/underfitting
- The test shows an accurate prediction of SSIM and FPS indices
- Generalisation to different 3D mesh

Loss at 150 epochs	MSE
Training	2.8e-5
Validation	4.2e-5
Test	5.69e-4



Conclusion

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- We realised a deep learning model that accurately predicts objective quality metrics
- Our model provides a selection tool for the optimal level of detail to render
- The quality of experience can improve by addressing the main factors that impact VR immersion

Thank you

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