**THESIS REGISTRATION**

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Advisor Name: Assoc. Prof. Nguyen Van Sinh Semester: I Year: 2023 - 2024

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| **TOPIC SUMMARY** | |
| **Topic** | **Processing the 3D heritage data samples based on Graph Neural Network** |
| **Field** | **Computer Sciences** |
| **Specialty** | **Geometric modeling, Machine learning, Computer graphics, and Images processing** |
| **Keywords** | **3D samples, Object denoising, Digital heritage, Surface mesh, Machine learning, Graph neural network** |
| **PROBLEM DESCRIPTIONS** | |
| 1. **Motivation**   Heritage objects have valuable history as they link to cultural and natural assets that have significant value to society. 3D reconstruction of heritage objects is an emerging topic. Many efforts have been started to digitalize the heritage around the world. Moreover, the surface of these heritage objects contents noisy parts over time. Two famous architectures (GAN [1] [2] and Autoencoder) in deep learning show that learned models can encode and generate new data. For instance, the neural network model can be trained to remove noisy information and create a completed object. Therefore, we can reconstruct these heritage objects and make them close to their original ones.  Due to these problems, this thesis proposes an improved method for denoising 3D objects from scanned data. After that, we combine with the existing heritage data to train the model. At the end, we integrate our training model in a web-based application for researchers.   1. **Objectives**   The objective of this thesis includes:   * Researching existing neural networks methods applied in 3D data processing to find the best model for denoising heritage dataset. * Collecting and reconstructing data of heritage objects. The obtained dataset is then processed to enrich its features. * Creating a graph neural network architecture to denoise the 3D objects. * After training the model, we integrate it on a web application for contributing to the communities in the field.  1. **Methodology** 2. **Collect dataset**   Deep learning models need large amounts of data to learn patterns and make accurate predictions. In our case of restoring 3D objects, the model needs to discover general information from training data to reconstruct unseen data effectively. That is why we need as much data as possible. We collect data by using the following methods:   * Using a 3D scanner to collect data: The first approach involves using a 3D scanner to collect data directly from real-world objects. A 3D scanner captures the shape and appearance of physical objects, creating a digital representation as a 3D model. * Using existing data from others' research [3]. This method can help us reuse existing 3D datasets from previous research projects. * The obtained dataset is the classified into two packages (noise dataset and ground truth dataset).  1. **Denoise data**   Because of geometrical characteristics, 3D objects may fall into one of the following data types ((i) Voxel [4]: the most straightforward representation of 3D data. It works like an extension of the pixel in a 3D space. The limitation of this representation is not memory efficient. (ii) Point Cloud [5]: an alternative way to represent 3D geometries, but the data is disconnected. It is just a list of points in space without any relationship. Therefore, it is hard for the model to learn the information from these points. We also need post-processing to get the result. (iii) Surface mesh [6]: the best 3D representation that saves memory and computation efficiency. Many heritage objects are structured in this form). Therefore, we use the Graph Neural Network (GNN) and its variant GCN [7], FeastConv [8], etc. Moreover, we combine the GAN [1] [2] and autoencoder models to create the final neural network.   1. **Implement on web-based application**   Our training model is now integrated on a web application. This platform allows users, researchers access and use for different purposes.   1. **Expected results.**  * A dataset for reconstructing heritage objects. * A graph neural network for denoising 3D heritages. * A comparison of different methods in reconstructing 3D objects using both geometric modeling and machine learning techniques * A web application to show our results. * A thesis report. * A publication of our proposed method and obtained results.  References  |  |  | | --- | --- | | [1] | Ian J. Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, Yoshua Bengio, "Generative Adversarial Networks". | | [2] | A. Radford, L. Metz and S. Chintala, *Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks,* 2016. | | [3] | Peng-Shuai Wang, Yang Liu, Xin Tong, "Mesh Denoising via Cascaded Normal Regression". | | [4] | A. Brock, T. Lim, J. M. Ritchie, and N. Weston, Generative and discriminative voxel modeling with convolutional neural, 2016. | | [5] | P. Achlioptas, O. Diamanti, I. Mitliagkas, and L. J. Guibas, "Learning representations and generative models for 3D point clouds," in *PMLR*, 2018. | | [6] | A. Ranjan, T. Bolkart, S. Sanyal, and M. J. Black, "Generating 3D faces using convolutional mesh autoencoders," in *ECCV*, 2018. | | [7] | Thomas N. Kipf, Max Welling, "Semi-Supervised Classification with Graph Convolutional Networks". | | [8] | Nitika Verma, Edmond Boyer, Jakob Verbeek, "FeaStNet: Feature-Steered Graph Convolutions for 3D Shape Analysis". | | [9] | Yuefan Shen, Hongbo Fu, Zhongshuo Du, Xiang Chen, Evgeny Burnaev, Denis Zorin, Kun Zhou, Youyi Zheng, "GCN-Denoiser: Mesh Denoising with Graph Convolutional Networks". | | [10] | Yingkui Zhang, Guibao Shen, Qiong Wang, Yinling Qian, Mingqiang Wei, Jing Qin, "GeoBi-GNN: Geometry-aware Bi-domain Mesh Denoising via Graph Neural Networks". | | |
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| **WORK PLAN**  **Phase 1: Data Gathering**  **Duration: 22/12/2023 to 31/12/2023**  Collect a dataset of heritage objects through scanning and data acquisition techniques.  **Phase 2: Exploring Software and Frameworks**  **Duration: 1/1/2024 to 15/1/2024**  Explore the Qt framework to understand its capabilities.  Familiarize with the MeshLab software to reuse its mesh processing and visualization functionalities.  Study the VCG library to apply it in 3D heritage restoration tasks.  Use MeshLab to create a training dataset.  **Phase 3: Literature review**  **Duration: 16/1/2024 to 15/2/2024**  Compare the results of existing methods used for 3D heritage denoising.  Analyze the advantages and disadvantages of each method.  **Phase 4: Implementing and training the model.**  **Duration: 16/2/2024 to 29/02/2024**  Develop a model and train it with our dataset.  Write a draft report detailing the research, methodology, and initial results.  **Phase 5: Evaluate model**  **Duration: 1/3/2024 to 31/3/2024**  Evaluate the trained model.  **Phase 6: Implement web-based application**  **Duration: 1/4/2024 to 15/4/2024**  Implement a web application to show the result.  **Phase 7: Test and fix bug**  **Duration: 16/4/2024 to 30/4/2024**  Fix the application and continue training the model if needed.  **Phase 7: Finalizing thesis and document**  **Duration: 1/05/2024 to 31/05/2024**  Prepare all the required documentation and materials for thesis submission.  **Phase 8: Submission and conclusion**  **Duration: 1/6/2024**  Submit the final thesis report and the completed demo software as required.  Conclude the research project. |
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