VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Pengpeng Hu**

The public defense will take place on **Wednesday, 21st September 2022 at 10:00am.**

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DEEP LEARNING-BASED 3D HUMAN BODY SHAPE RECONSTRUCTION FROM POINT CLOUDS

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Abstract of the PhD research

3D reconstruction of the human body shape is a fundamental problem in computer vision, which is valuable for various human-centric applications such as computer animation, virtual reality, and clothing design, to name a few. 3D scanning is a popular technology for acquiring the geometry of a subject based on which a 3D body reconstruction can be produced. Although countless body scanners were developed to meet different industrial requirements and a lot of advanced algorithms were proposed for optimizing the reconstructed body models, many problems are still not properly solved. These problems, however, are difficult to address using conventional methods. Recent years have witnessed the rapid development of artificial intelligence, especially deep learning. Following this trend, we proposed deep learning-based solutions to several challenges existing in modern 3D body scanning and reconstruction.

In this thesis, we focus on four challenges of 3D body scanning, namely, (i) estimation of body shape under clothing, (ii) body reconstruction from impaired point clouds, (iii) registration of non-overlapping point clouds, and (iv) animatable body reconstruction using a single depth camera. The first challenge arises from the fact that existing 3D scanning solutions require the subjects to get scanned with minimal clothing as the scanning device can only record the outmost surface of objects. This scanning procedure is inconvenient to most people and is also an infringement of the right to privacy. The second challenge comes from the observation that impaired point clouds are common in practice but they lack a systematic study. Moreover, the problems of misalignment and problematic posture are neglected in existing solutions. The third challenge is a classical problem: partial point cloud registration. We found that existing methods mainly rely on the assumption that the source and the target point clouds have sufficient overlap and none of them could handle non-overlapping registration. The last challenge is addressed as many applications demand dynamic human body models. Traditional methods require expensive professional devices to produce such models.

Our first contribution is to propose the first deep learningbased method in the literature for estimating the body shape under clothing from a single 3D dressed body scan. A novel dataset consisting of large-scale dressed body scans and corresponding ground-truth body shapes is proposed. Our second contribution is a novel deep learning approach for jointly reconstructing an accurate body mesh and normalizing the posture of the human body model from a low-quality body point cloud in arbitrary postures. Our third contribution is the first deep learning-based method in the literature to align non-overlapping partial point clouds. Using this method, an omnidirectional body can be obtained from only two non-overlapping body scans. The last contribution in this thesis is to propose a novel deep learning-based method to reconstruct an animatable body shape from only two depth images and at the same time allowing for large pose variations between the camera shots.