摘 要

一个完整的三维扫描系统通常分为相机标定、图像预处理、特征提取、立体匹配、三维重建等部分。三维重建的方法分为主动式和被动式两种。基于结构光的三维重建技术属于主动式的一种，具有精度高，测量速度快，稳定性好等优点，得到了广泛的研究和使用。基于结构光的重建方法分为点结构光法、线结构光法和编码结构光法，本文采用的是编码结构光的方法。一个编码结构光扫描系统通常包含一个摄像机和一个投影仪，通过投影仪投射黑白相间的条纹到目标物体，使用相机拍摄多组具有不同条纹的目标物体，通过对获得的图像进行解码计算得到物体的位置和深度等信息。

本文讨论的是三维重建技术在人脸的应用，本文的三个主要贡献是：提出一套基于开源库的点云预处理流程的简单稳定的工程实现方案；提出一种基于人脸图像改进的点云配准改进方法；提出一种基于人脸特征点的纹理融合算法；基于 OpenCV 和 CGAL 开源库在 Qt 平台上开发一套高精度人脸三维重建系统。本文讨论了从点云生成之后的滤波处理到最后多片点云的合并以及纹理贴图的详细的算法与实现。

点云的预处理包括点云的降噪、平滑、点云简化和点云的法向计算。点云的配准分为粗配准和精确配准两个步骤，本文的贡献是通过人脸检测的方法得到人脸的关键点再根据相机参数计算对应的三维坐标。将两片点云对应的人脸特征点的三维坐标作为粗配准的输入，将其中一片点云所在的坐标系作为目标坐标系。通过计算最小平方误差得到另一片点云变换到目标坐标系的旋转平移矩阵，并且进行坐标变换，再通过多次最近邻迭代的方法，使两片点云较为精确的拼接成一片点云。通常的纹理融合方法是通用的，实现复杂，并且效果不理想，本文根据人脸的几何特征提出了一种仅适用于人脸的简单易用的算法，并且效果良好。该算法将人脸近似为一个圆柱体，根据人脸特征点的三维坐标，进行坐标变换，是人脸表面贴近圆柱体表面，再根据经典的加权融合的思想计算人脸表面某一点对多张纹理图的二维点取色的输入权重。

关键词：三维重建 纹理融合 网格简化

ABSTRACT

A complete 3D scanning system is usually divided into camera calibration, image preprocessing, feature extraction, stereo matching, 3D reconstruction and so on. The methods of 3D reconstruction are divided into active and passive. The three-dimensional reconstruction technology based on structured light is an active one, which has the advantages of high precision, fast measurement speed and good stability, and has been widely studied and used.The reconstruction method based on structured light is divided into point structure light method, line structure light method and code structure light method. This paper uses the method of coding structured light. A coded structured light scanning system usually includes a camera and a projector, which projects black and white stripes to the target object through the projector, uses the camera to shoot multiple sets of target objects with different stripes, information such as the position and depth of the object can be obtained by decoding the obtained image.

This paper discusses the application of 3D reconstruction technology in human face. The three main contributions of this paper are: a simple and stable engineering implementation scheme based on the open source library's point cloud post-processing process; a method based on face image improvement is proposed. An improved method of point cloud registration is proposed. A texture fusion algorithm based on face image feature points is proposed. Based on OpenCV and CGAL open source library, a high-precision face 3D reconstruction system is developed on Qt platform. This paper discusses the detailed algorithm and implementation of the filtering process from point cloud generation to the final multi-slice point cloud merging and texture mapping.

Point cloud preprocessing includes point cloud noise reduction, smoothing, point cloud simplification, and point cloud normal calculation. The registration of point cloud is divided into two steps: coarse registration and precise registration. The contribution of this paper is to obtain the key points of the face through the face detection method and calculate the corresponding three-dimensional coordinates according to the camera parameters. The three-dimensional coordinates of the face feature points corresponding to the two point clouds are used as the input of the coarse registration, and the coordinate system in which one of the point clouds is located is

taken as the target coordinate system. By calculating the least square error, Rotational translation matrix by which another point cloud transformed to the target coordinates is obtained, and the coordinate transformation is performed, and then the method of multiple nearest neighbor iterations is used to make the two point clouds more accurately spliced into a point cloud. The usual texture fusion method is general, the implementation is complex, and the effect is not ideal. According to the geometric features of the face, this paper proposes an easy-to-use algorithm that is only applicable to human faces, and the effect is good. The algorithm approximates the face to a cylinder, and performs coordinate transformation according to the three-dimensional coordinates of the face feature points. The facet of the face is close to the surface of the cylinder, and then the point of the face is calculated according to the idea of classical weighted fusion. The input weights of the two-dimensional points of multiple texture maps to a certain point on the face are calculated.

Key Words: Three-dimensional reconstruction, Texture fusion, Mesh simplification