A Bio-Inspired Strategy for 3D Surface Reconstruction of Unstructured Scenes Applied to Medical Images

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***Abstract*—The use of 3D reconstruction, along with immersive technologies, is a technique used in several areas of research and development. Currently, the most common strategy for performing this type of reconstruction is using a stereoscopic camera model. The problem worsens when the challenge involves unstructured scenes, which are scenes that have an ill-defined cognitive architecture. The present work proposes a methodology for 3D reconstruction of unstructured surfaces using monocular cameras. Thus, modern AI techniques, Computer Vision and Computer Graphics techniques have been applied to solve this problem. The experiments performed in this work can be concluded that the proposed method can reconstruct structured scenes with a hit rate between 63% and 68%, depending on the number of thresholds used in the segmentation, thus being superior to the classical method, where the extraction of points is done over the original image without any pre-processing.**

***Index Terms*—3D reconstruction, Image Segmentation, SIFT, Unstructured surfaces, Medical Images**

I. Introduction

In 3D reconstruction, when the environment has a familiar structure to the human eye, navigation is usually more intuitive due to the detection and recognition of points of interest. This kind of scene can be called a structured scene. On the other hand, when these points are not present the scene usually has no similar structure to the human brain, so the scene may be called non-structured or unstructured, scenes.

An example of structured scenes maybe those captured from familiar internal environments, such as a house, an office, or a hallway in a building. Whereas, examples of unstructured scenes are usually: sub-aquatic scenes, internal biological organs, post-disaster or microscopic images.

The demand for reconstruction, visualization and navigation applications in unstructured environments has increased over time, especially in minimally invasive surgery procedures, with impacts in several points, such as surgery time, patient recovery and hospital bed occupancy. Likewise, underwater navigation for oil exploration or studies of marine biology and geology may also be facilitated if the surface reconstruction process for this type of navigability, generally robotic, were more feasible.

It is possible to retrieve the necessary parameters to perform a camera calibration and estimate the depth of a scene that was, in its original form, a bi-dimensional image. However, in an unstructured scene, like medical images, some problems arise in the three-dimensional reconstruction of the scene due to poor illumination and a large amount of noise on the scene. The segmentation of the scene can be a promising solution to these problems.

The proposed methodology uses AI and computer vision techniques that have been gaining space in the market and research centers. Based on the proposed methodology, some potential applications can be exemplified as follows.

Surgery simulation is one of the possible applications. With the reconstruction of a surgery room and, mainly, the reconstruction of a patient's body, a surgery training room can be simulated, thus, avoiding possible errors in the surgery.

Another notable example is the simulation of unstructured scenes. Reconstructing these kinds of environments, an exploration in a dangerous cave could be accomplished without risking the life of a human being.

Besides unstructured environments, it is possible to simulate structured environments as well, such as a factory to improve the visualization of the production line in order to optimize logistics, timing, etc.

In a virtual world, a conversation between two persons in the same room can be simulated through virtual reality, even if their geographical locations are distant in the real world.

With that in mind, this paper proposes a new methodology to reconstruct three-dimensional surfaces, that substitute the use of stereoscopic cameras by a single monocular camera, combining modern computer vision and computer graphics techniques to achieve a similar surface of the captured image, being from a structured or unstructured scene, allowing three-dimensional interaction with the surface.

The main contributions of this paper are:

1) A method to reconstruct 3D surfaces that uses a bio-inspired algorithm to segment the image, along with a feature extraction algorithm to improve the reconstruction quality.
2) The exposition to the problem of matching points obtained by the feature extractor, SIFT, on unstructured images.