Mesh Adition Based on the Depth Image (MABDI)

Lucas Chavez[1] and Ron Lumia[2]

***Abstract*— The goal of this work is to design a method which can create a reliable mesh representation of the environment from sequential registered noisy point cloud data sets. We will name this method MABDI which stands for Mesh Adaptation Based on the Depth Image. The method must be computationally feasible for online applications and have a low memory requirement. In addition, the method must update the representation when new measurements of revisited parts of the environment are made.**

I. Introduction

Many robotic applications, especially those that involve human robot interaction, often require a rich representation of the environment in order to perform such behavior as path planning and obstacle avoidance. In general, a rich representation, or map, is useful for providing situational awareness to an autonomous agent. A map is also important for applications such as teleoperation [1].

The methodology to build this representation is a continuously evolving subject in the field of robotics. The origins of the research into this problem dates back roughly 25 years [2]. Since then the methods and the representations themselves have continued to evolve at an impressive rate. The main catalyst behind this growth is the advancement of sensing technologies over the same time period. In general, sensors have continued to generate measurements at higher rates, higher resolution, and lower cost over the years. This has provided an amazing opportunity to build richer and more useful representations of the environment.

In robotics map building in an unknown environment is referred to as the Simultaneous Localization and Mapping (SLAM) problem [3]. This label describes the fact that a methodology which solves the SLAM problem must simultaneously locate the robot in the environment as well as map the environment.

The focus of this work is the mapping aspect of the SLAM problem. Early mapping methods represented the environment as a set of landmark locations. The result was a sparse set of points usually on a 2D plane. This allowed research to show that their SLAM solutions worked but it soon became clear that a richer representation of the world was needed for a growing number of applications. In response several methods were developed using various other representations. A number of representations are compared in Table I.

	Adaptability	Computationally Inexpensive	Low Memory Requirement	SA: Robot	S Hu
Landmark Locations	x	x	x	-	
Point Clouds	-	x	-	-	
Surfels	x	x	x	-	
Implicit Functions	x	-	-	x	
Static Mesh	-	x	x	x	
Adaptive Mesh	x	o	o	x	

TABLE I

CHARACTERISTICS OF CURRENT FORMS OF REPRESENTATION

Table I compares the characteristics of map the representations. Adaptability describes the ability of the representation to correct itself given new information. Computational expense describes how difficult it is to create and maintain a representation. Memory requirement describes how much memory a method must use to run. Situation Awareness (SA) describes how well suited a representation is for both robot and human decision making. Robot decision making requires a representation that can be used for such problems as obstacle avoidance. Human decision making requires a method that can be allow an operator to intuitively understand the state of the robot given the map. The Table is supposed to reflect what a representation is capable of and not necessarily where the state-of-the-art is.

A mesh based representation is arguably an extremely good choice in comparison to the other representations. It has been used extensively by the gaming community because it is the best for representing large environments with the minimum memory. Also, this sort of representation works well to increase the SA of a robot because methods for performing physical simulations such as obstacle collision detection already exist. In addition, a mesh based environment is a very natural method to display information to a human operator.

Currently, the problem with mesh-based environmental mapping techniques is that they are greedy in the sense that the mesh elements can not be corrected using new information. Once the mesh is in place there is no mechanism to adapt to newer measurements. The problem of adapting a mesh to new information is a very well studied problem in computer graphics, but these methods were not designed with large scale environmental mapping in mind. The biggest questions are:

- How can we quickly decide which measurements should be used to adapt which part of the mesh?
- How can we quickly detect new and removed objects?
- How can we robustly deal with noise and obtain a

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[1]Lucas is with Mechanical Engineering Department and Electrical & Computer Engineering Department, University of New Mexico, Albuquerque, NM, USA {lucasc,lumia}@unm.edu

methodology that makes use of the new measurements of an already existing part of the representation?

So the real question is can we develop a methodology that can address all of the above questions and still have a manageable memory requirement and be computationally feasible? The goal of this work is to show that MABDI is capable of addressing these questions.

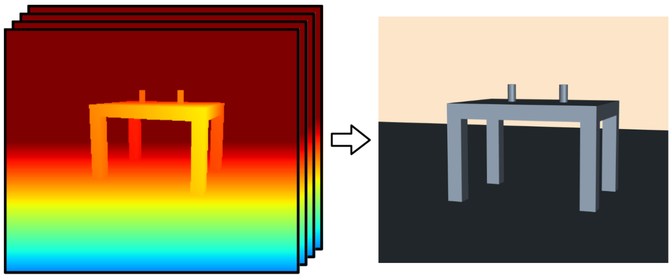

Fig. 1. In this work, the goal of mapping is to generate

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