International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 11, November - 2013

Image Processing of 3D Objects with Mathematical Aspects of Camera & Mathematical Aspects of Image

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Abstract

When you have two normally functioning eyes, depth perception is primarily anchored in the fusion in your mind of the two images that come from your eyes – each one offset slightly from the other. In 3D image processing, by taking two photographs with a left and right displacement, you replicate this aspect of your vision. Mathematical abstraction for surface of 3D object is "embedded 2D manifold". A statistician's view, we have a set of data -surface points produced by the sensor. We want to "fit a parametric model" to these data, in our case a 2D manifold. With help of 3D image processing we can present the image in attractive manner. 3D Image processing is an active, exciting research area.

Keywords- *Cues, Binocular vision, hyperstereo, Depth perception, tracking, manifold, Mathematical aspects of camera, Mathematical aspects of image.*

Introduction

More and more people are getting into 3D image processing every year. No wonder: You can use all kinds of digital cameras and other devices and programs to create 3D images if you know what to do. With the right equipment you don't have to know a lot: many new cameras and mobile phones have two lenses for taking 3D photos. Creating spectacular 3D photos has never been this easy! Though more people are getting into 3D image processing every year, it is not a new thing. In fact, it has been around for over a century and a half. It is simply a method of photographically recreating what you already most likely do: perceive depth in everything you see. You have two eyes and you see a slightly different live "image" with each eye. To recreate this in image processing, you simply need to take two photos from slightly different positions. Standard photographs are only a two-dimensional representation of the world around you. Three-dimensional photos are taken from two perspectives, roughly reproducing what your two eyes perceive. By forcing each eye to see only one of the photographs – the left eye sees only the left photograph and the right eye sees only the right photograph – you can recreate this dimensional world. Your brain will reconstruct the two images into a single 3-dimensional image. There are a variety of ways to view these resulting images, and a variety of ways to take them. Just like normal two-dimensional image processing, you can also manipulate this 3D world and have some fun creating some alternate realities along the way! This book will go through the process of describing a variety of equipment you can use, from the camera you already own (no extra cost) to equipment you can buy if you decide to step it up and take some seriously good 3D pictures. You will also be guided through the various ways to view 3D images, from glasses to free viewing with your eyes, to various 3D displays that are beginning to become commonplace.

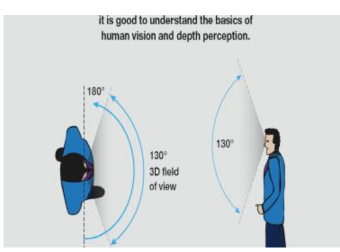
In further part we are going to see mathematical aspects of the 3D image processing. In this aspect we get the information about the camera adjustments, Combinational structure of camera parts for taking photographs. Further in this presentation we discuss about mathematical aspects of size, shape & model of 3D image. The important factors involved in it. The upcoming new milestone in the 3D technology.

Basic concepts of 3D image processing

When you have two normally functioning eyes, depth perception is primarily anchored in the fusion in your mind of the two images that come from your eyes – each one offset slightly from the other. This offset is the best cue we have as to the depth in a scene; however, there are other cues as well. Besides this ocular separation and the different viewpoints sent to the brain, there are cues such as motion – either as you move through a scene or an object moves through a scene. You have a wealth of knowledge in your head about the size of objects, from people to objects such as cars or books or myriads of other objects. You know approximately how big they should be, so the relative size on your retina and relative size to other

An object gives you instant cues to the object's distance. This is also the part of depth perception that is easily fooled by optical illusions using wrong-sized common objects to fool the brain.

Other cues come from our eyes' rather expansive field of view, nearly 180 degrees horizontally and approximately 130 degrees vertically (biased towards the ground). The placement of objects with respect to this broad canvas of ground and sky (or floor and ceiling) in our field of view does much to Place the object in space.



CUES INVOLVED IN 3D IMAGE PROCESSING

In 3D image processing, by taking two photographs with a left and right displacement, you replicate this aspect of your vision: You create two perspectives with two scenes. . Once you have the two photos, you need to separate the left and right images to the respective eye. Binocular vision is the main cue for depth perception, but it is not the only cue. The wide field of view also matters, and when you take a photograph, you typically take a narrower field of view than the eye can see. As a result, you are missing a few cues for depth and this means that sometimes a 3D photo can seem shallower or the objects can take on the appearance of cardboard cutouts. You can compensate for this by taking photos at a wider distance apart than the eyes, which creates an effect called hyperstereo. This can be pleasing up to a point, and is part of the creative process of taking 3D photos. Another difference you will notice right away when viewing a 3D photograph is that when you move your head around, you cannot see behind the object like you can in real life. Since it is just two 2D photographs, There is nothing to be revealed by trying to "peek around" in 3D. As a result, the photo appears to move with your head- something call "tracking."

When you move your head left, the scene also seems to move to the left, with the objects closer to you moving more quickly. Move your head right, and the closest objects in the picture will track to the right quickly, as if to "cover up" what you will never be able to see. Those limitations are minor, though, and you will soon discover that taking 3D photos is a world of fun and introduces, literally, a Whole new dimension to your image processing.

MATHEMATICAL ASPECTS OF CAMERA

A regular 3D camera (B~55-75mm) can be used for close-ups provided that we do the following:

- Block background
- Move back and zoom-in
- Or, use wide angle lenses

P = M B = FB/I

The Advantage of Digital

1. Lightweight cameras

ISSN: 2278-0181
Vol. 2 Issue 11, November - 2013

2. Alignment via Software
3. Quick Preview

Digital cameras are usually smaller, lighter, and more compact, because there is no need for film to run through them. The end result is a smaller and lighter macro 3d outfit, an advantage when working in the field. Alignment is not as critical and alignment or distortion errors can be correctedin post processing with software. It is possible to have a quick preview of the results and make any necessary adjustments. This is important since macro 3d image processing is, in many cases, a trial and error method.

A regular stereo camera is not the ideal tool to take a close-up 3d picture.
Here is why:
• To take a close-up we need to get closer to the subject to increase the magnification.
• As we get closer, the amount of depth increases.
• There is point when the picture has to much depth and cannot be fused or viewed comfortably.

To take a close-up/macro 3d picture, you need to reduce the spacing of the lenses (Stereo Base, B)
Rule of thumb: B = 1/30 x Distance of near Object

FOR CALCULATION OF PARALLX

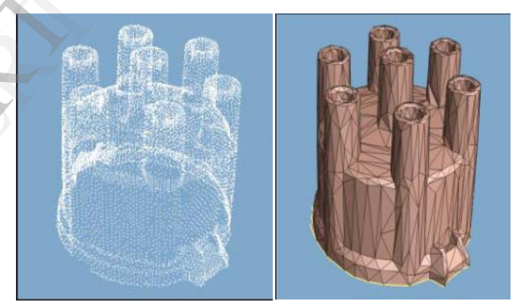
M = Magnification = F/I
F= Focal Length, I = Object distance
As we get closer (I get smaller), M gets larger and P also gets larger. There is a point where Parallax gets too large and the image cannot be fused viewed comfortably

Blocking Background
• Blocking the background (always helps to reduce P) because Ifar becomes smaller. In the special case where the subject has limited depth:
P = F B (1/Inear - 1/Ifar) = F B (Ifar Inear)/(Inear*Ifar)
P = F B (Subject Thickness**)/I2**
• If there is little depth (background blocked) then **moving back** (2I) and
Zooming in (2F) results in reducing P (P/2)
P = FB/I = FB (1/Inear—1/Ifar)

MATHEMATICAL ASPECTS OF IMAGE

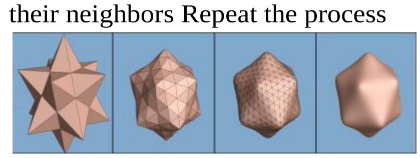
Mathematical abstraction for surface of 3D object is “embedded 2D manifold” (subset of 3D space that locally looks like a piece of the plane) Study of 2D manifolds has a long history going back to Gauss and Euler Important result: There are infinitely many fundamentally different 2D manifolds that cannot be smoothly deformed into each other: impossible to deform balloon into coffee cup without tearing .This fact accounts for some of the difficulties in 3D image processing.
A statistician’s view, we have a set of data -surface points produced by the sensor. We want to “fit a parametric model” to these data, in our case a 2D manifold. Parameters of model control shape of the manifold. We define a goodness-of-fit measure quantifying how well model approximates data. We then find the best parameter setting using numerical optimization.

Fitting 2D manifolds, Real world objects are often smooth or piecewise smooth. Modeling a smooth objects by a mesh require lots of small faces. Want more parsimonious representation.



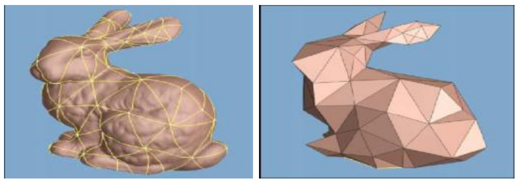
SENSOR DATA FITTED MESH

Subdivision surfaces
Defined by limiting process, starting with control mesh (bottom left)Split each face into four (right)Compute positions of new edge vertices as weighted means of corner vertices Compute new positions of corner vertices as weighted means of their neighbors Repeat the process



Computational Differential Geometry

Partitions mesh into triangular regions each homeomorphic to a disk. Create a triangular “base mesh” associating a triangular with each of the mesh. Construct a piecewise linear homomorphism from each region to the corresponding base mesh face. Now we have representation of original as vector function over the base mesh. Multi-resolution analysis of function is well understood.



PL-HEMOMORPHISM

CONCLUTION

Casting 3D photography into the language of Mathematics and Statistics allows one to bring to bear the tools of these fields. Depth perception is primarily anchored in the fusion in your mind of the two images that come from your eyes – each one offset slightly from the other. Mathematical abstraction for surface of 3D object is "embedded 2D manifold". This offset is the best cue 3D Image processing is an active, exciting research area. There is opportunity, and need, for contributions from Computer Science, Mathematics and Statistic.

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