**3-D Shape from Texture**

**Izza Tariq**

**Purdue University**

**Abstract**

The purpose of this study was to implement an existing shape-from-texture algorithm and test the efficiency of the algorithm in the context of custom-made abstract textures. We investigated whether the 3D surface generated by the algorithm looks logically correct or similar to the texture given as input. The algorithm is based on Loh’s method of recovery of 3D-structure using visual texture patterns (Loh, 2006). Slight new adjustments were introduced to make the algorithm more efficient. The following assumptions were taken into account: image is viewed orthographically, is composed of texels and has a homogenous and stationary texture. The estimation of the frontal texel from the original image is done manually by the user. Algorithm was tested on both real and synthetic images designed in photoshop.

**Introduction**

Creating 3D shape from a texture image is a very important problem in computer vision as it is a forerunner to the task of object recognition and modeling in the field of computer graphics (Loh, 2006). Apart from texture there are many other visual cues that provide 3D information about a surface. Some of these include, shading, occluding contours and multiple images of a scene taken from different views. The significances of these cues are discussed further in the literature review section. An important point to note is that none of these cues alone is sufficient in providing 3D information of a surface or object (Burge, 2016). This is leading researchers to investigate how the human visual system is able to combine multiple cues to extract complete and accurate 3D information of a scene (Burge, 2016). It can also be argued that a particular visual cue can have a higher weightage over the other depending on its abundance in a scene or image.

Texture plays an important role in the human perception of shape according to psychophysical experiments (Loh, 2006). An advantage of texture as a visual cue over other visual cues is that it requires only a single image to infer the 3D shape of a surface. At the same time, it can be combined with information from other visual cues to achieve a more accurate estimate of shape (Loh, 2006). Another motivation for studying texture as a shape cue is that not a lot of research has been done in this domain recently.

In the context of our study, texture is defined as a 2D image composed of discrete geometrical elements also known as texels.

* Introduce your topic.
* Create some context and background.
* Tell your reader about the research you plan to carry out.
* State your rationale.
* Explain why your research is important.
* State your hypothesis.

Idea Suppose that a texture is composed of individual texels, and that one texel is known to be viewed frontally in an image. Other texels may be slanted away from the camera, and lie at a different distance from the camera than the frontal texel. Slanting the texel will cause foreshortening in the tilt direction1 , and changing distance from the camera will result in a change of scale. The appearance of any texel will be related to the appearance of the frontal texel by a geometric transform, which locally can be modeled as an affine transformation. By measuring at each texel the affine transformation that relates that local texel to the known frontal texel, we may determine the orientation of the surface at that point in the image. From this information it is possible to reconstruct the surface. Sometimes however, no frontal texel is visible, or identifiable in the ……. (Shape from non-homogeneous, non-stationary, anisotropic, perspective texture)

**Literature Review**

Extracting 3-D shape from a texture is a very popular problem in computer vision that can provide useful information about the structure of an object or surface in the image. It was interesting to find out that despite a lot of journal papers published in this area, there are very few methods that actually estimate 3D shape from texture (Forsyth, 2002). All these methods take certain assumptions into account and give far from perfect results. Moreover, most of these papers were published before 2005 which points to the lack of recent research conducted in this area.

The first person who showed interest in the idea of using texture as a cue for 3D shape was Gibson (Gibson, 1977). Following this, a lot of methods were developed that assisted in the generation of 3D shape from images using different properties of texture. However, most of these were common in that they all involved some assumptions or restrictions regarding texture and camera models. Witkin (Witkin, 1981) and Brown (Brown, 1990) developed a method that was constrained by isotropic textures. Homogeneity in texture is another constraint that many other methods took into account such as the method proposed by Kanatani (Kanatani, 1989). Work done by Malik (Malik, 1997) assumes stationarity in their textures. Such textures could not include rotated texture elements.

A variety of techniques has been employed by different people to analyse and extract information from textures and use that to deduce the shape of the textured surface. Some of these involved extracting the spectral information from images, (Loh, 2006). Fourier transform, wavelet decomposition and Gabor transform are some of the spectral representations. An advantage of spectral approach is that errors made in the image domain while extracting texture patches get discarded in the phase part of the spectral representation (Loh, 2006). Other techniques involve developing a differential framework as Garding did (Garding, 1992). In his work, Garding derived relationships between change in texture gradients and differential geometry of curved surfaces. However, his textures assumed both isotropy and stationarity.

My research would be mostly based on Loh’s dissertation work. Loh talks about two different methods that she implemented. One involves extracting the frontal texture manually while the other one does not. The first method also assumes that textures are constrained by homogeneity, stationarity and isotropy and are viewed orthographically. The second method gets rid of all these constraints and deals with perspective textures. As mentioned before, my work would be based on the first method.

**Methodology**

**Results**

**Discussion**

**Conclusion and Future Work**

**References**

Loh, A. M. (2006). The recovery of 3-D structure using visual texture patterns. (Doctoral

dissertation). Retrieved from National Library of Australia. (Accession No. 225346721)

Aloimonos, J. (1988). Shape from texture. *Biological Cybernetics,58*(5), 345-360.

doi:10.1007/bf00363944

Brown, L., & Shvaytser, H. (1990). Surface orientation from projective foreshortening of

isotropic texture autocorrelation. *Proceedings CVPR 88: The Computer Society*

*Conference on* *Computer Vision and Pattern Recognition*. doi:10.1109/cvpr.1988.196283

Burge, J., Mccann, B. C., & Geisler, W. S. (2016). Estimating 3D tilt from local image cues in

natural scenes. *Journal of Vision,16*(13), 1-25. doi:10.1167/16.13.2

Forsyth, D. A. (2002). Shape from Texture without Boundaries. *Computer Vision — ECCV 2002*

*Lecture Notes in Computer Science,*225-239. doi:10.1007/3-540-47977-5\_15

Gårding, J. (1992). Shape from texture for smooth curved surfaces. *Computer Vision — ECCV92*

*Lecture Notes in Computer Science,*630-638. doi:10.1007/3-540-55426-2\_67

Gibson, J. J. (1977). *The perception of the visual world*. Westport: Greenwood Press.

Kanatani, K., & Chou, T. (1989). Shape from texture: General principle. *Artificial*

*Intelligence,38*(1), 1-48. doi:10.1016/0004-3702(89)90066-0

Loh, A. M., & Hartley, R. (2005). Shape from non-homogeneous, non-stationary, anisotropic,

perspective texture. *Procedings of the British Machine Vision Conference 2005*.

doi:10.5244/c.19.8

Malik, J., & Rosenholtz, R. (1997). A differential method for computing local shape-from

texture for planar and curved surfaces. *Proceedings of 27th Asilomar Conference on*

*Signals, Systems* *and Computers*. doi:10.1109/acssc.1993.342575

Witkin, A. P. (1981). Recovering surface shape and orientation from texture. *Artificial Intelligence,17*(1-3), 17-45. doi:10.1016/0004-3702(81)90019-9