Indian Institute of Technology
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Project Proposal

Study of Refractive effects in Digital Images

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ABSTRACT

Light bends when encounters an interface with mediums of different refractive index. This phenomenon is not dealt in the image capturing by the camera. Various effects like change in the depth and size of the object come into play. This makes the images of underwater objects taken from outside water distorted. This image now cannot be used to get idea of object parameters of depth and size. We ought to model this refraction by capturing images from air which is different from approaches followed.

INTRODUCTION

A camera observing a scene through air and water interface (underwater imaging) gives the illusion of scene being closer and magnified. Studying a system with multiple layers with unknown layer orientation, distances and refractive indices is a challenging problem. In this project we propose to study the effects that are crept in the images due to refracting media in the path of light from object to camera. We propose to model the basic physics of refraction and use that model to study the effects of refraction on digital images. With the model obtained we aim to find the refractive index of the medium from the images.

RELATED WORK

In the field of underwater imaging, various attempts have been made to model refraction through multiple interfaces and study its effects on images. Multi-layer refractive geometry has been explored in [1] in which with known scene understanding and known refractive index of the medium camera has been calibrated for the system involving refraction. In [2] epipolar geometry for scenes with refracting surface has been developed. It has been shown that refractive index can be found out from just one image using Snells Window when the camera is in the denser medium.

MOTIVATION

Taking good pictures of objects under the water from outside the water is a hard task. Various effects like refraction at the water air interface, reflection and polarization due to transmission from interface come into play of which refraction is the major problem. If we can model refraction and study its effects on the image being formed by the camera, it can help us to solve some high level problems like underwater object recognition. We can also improve the clarity of underwater vision as a whole.

OBJECTIVES

Study different images of the same object for modelling differences due to refraction, find refractive index with the above model.

APPROACH

- Modelling Refraction :- The pin-hole model for the camera does not take into account the effects of refraction on the images. We ought to introduce the concept of apparent depth in the model and understand the geometry for the systems with refracting medium between camera and object.
- Learn effects of refraction :-When refraction is considered in the camera model, the functional relations which we get are not explicit, and not sufficient, therefore we propose to use machine learning to learn the effects of refraction on images for different camera positions relative to the object. Machine learning can help us determine what features change in the image when we move the camera in some particular manner. Some of these changes are due to actual position change of camera while some are peculiar results due to refraction. Knowing those due to positional change of camera we ought to learn those due to refraction.

- Refractive Index :-The real depth of the point inside the refracting media is a function of the apparent depth of the point as recorded by the camera, the perpendicular distance between the water-air interface and the camera, and the co-ordinates of the point in the image-plane. By capturing multiple images of the object inside water with the camera oriented in different directions (or displaced along horizontal and vertical directions) with respect to the interface and using the functional relation above, we can find the refractive index of the medium..

APPLICATIONS

- Underwater Imaging :- Capturing images of not very deep objects inside water. With the refraction modelled, these images can be processed after capturing to remove refraction effects.
- Refractive index estimation:- With the help of digital images, refractive index of the medium can be estimated.
- 3D reconstruction:- Construct 3D geometry of underwater objects.

BUDGET AND RESOURCES

Fish Tank(₹ 1500), Tripod Stand and Head(₹ 5000), Light Sources(₹ 3500)
Multimedia Lab Facility

REFERENCES

[1] A. Agrawal, S. Ramalingam, Y. Taguchi and V. Chari. "A theory of multi-layer flat refractive geometry," in *Computer Vision and Pattern Recognition (CVPR), 2012 IEEE Conference*, pp. 3346-3353, 2012.

[2] V.Chari,P. Sturm. "Multiple-view geometry of the refractive plane." *BMVC 2009 - 20th British Machine Vision Conference*, pp. 1-11, Sep. 2009

[3] Anne Jordt-Sedlazeck, and Reinhard Koch. "Refractive Calibration of Underwater Cameras" *ECCV 5, volume 7576 of Lecture Notes in Computer Science, Springer*, pp. 846-859, 2012