INVESTIGATING THE DEPTH OF WATER USING AFFINE COMPUTATION

Sanmathi C K[1], Kavitha R[2]

M.E Communication Systems [1], Assistant Professor [2]

Department of Electronics and Communication Engineering

Bharathiyar Institute of Engineering for Women

(sanmathick@gmail.com)[1], (kavitharbe@gmail.com)[2]

Abstract: While we taking any picture which is near to the water field. The image in that reflection often exhibits bilateral symmetry. This kind of 3-D effect is popular in the photographic field. In this paper we determining the depth of the water from the reflection of the water reflected image. We first propose an rectification method to reduce the appearance differences between the real scene and mirror scene. Then we present 'dense stereo algorithm' especially to design the kind of symmetric scene, which is carried out to obtain the scene depth. In this project, We propose 'Affine computation algorithm' to determine the water depth from the reflection of the water images.

Key terms: *Bilateral symmetry, Rectification method, Dense stereo algorithm, Affine computation algorithm.*

1. INTRODUCTION

Water reflection is a common natural phenomenon and such scenes are popular among photographers. When the landscape is reflected by the water, the mirror scene and the real scene make up a symmetric scene. This symmetric scene can be used to produce a 3D scene with the property of symmetry. The principle idea is that the real scene and the mirror scene can be regarded as one seen from two viewpoints if the observer is not in the symmetry plane, meaning that the symmetric scene is equal to a pair of stereo images. Much work has been done about shape from symmetry, which focuses on man-made symmetric objects.

However, to the best of our knowledge, no published study has attempted to recover the depth from this special symmetry of water reflection. Where both natural and man-made objects may present. First, it is challenging to obtain correspondences between the real scene and the mirror scene in the water because of their appearance difference.

The two scenes have different illuminations and the mirror scene is usually distorted by the fluctuation of the water. Second, in a stereo system, if the object is too far away from the camera, its disparity will be close to 0 and the system cannot differentiate its depth from an object at infinity. Water reflection images often contain objects that are far away from the camera and the reconstruction of the scene depth from such images is not trivial.

2. RELATED WORK

The related work mainly includes two topics: symmetry detection and 3D reconstruction from symmetry. Symmetry detection is a fundamental and long-lasting topic in computer vision. Feature-based detection algorithms have been developed to detect planar bilateral symmetric objects. These approaches first find scale and affine-invariant features and then vote to obtain the axis of symmetry. Liu et al. provide a comprehensive survey of the literature. Early approaches to 3D reconstruction from symmetry often require user interaction or only reconstruct specific objects. Gordon et al. Deal with shape from symmetry and reconstruct objects marked with a regular grid. Later, Mitsumoto et al. build a symmetric scene using a mirror and reconstruct a 3D model with manually labeled correspondences. Franccois et al. also require labeled point correspondences to reconstruct a symmetric object. Jiang et al. calibrate the camera using a pyramid frustum, then recover a set of 3D points with the underlying symmetry, and finally adopt user interaction to reconstruct a complete 3D structure. Xue et al. detect symmetric line pairs from a symmetric piecewise planar object and then recover a depth map through Markov random fields. Automatic methods have been proposed recently for depth reconstruction from symmetric objects. Wu et al. detect the repetitions on a building and then utilize a dense stereo method to reconstruct its 3D relief model. Koser et al. match keypoints to find the symmetry plane, then reconstruct a depth map from a symmetric object using a global stereo approach. Sinha et al. reconstruct 3D curved models from textureless objects in images. All these approaches focus on man-made symmetric objects (such as buildings, cars, and chairs) with the same appearance on both sides of the symmetry plane.

3. PROPOSED WORK

The appearance of the mirror scene in the water often appears rather different from the appearance of the real scene, which can be seen from the following figures:

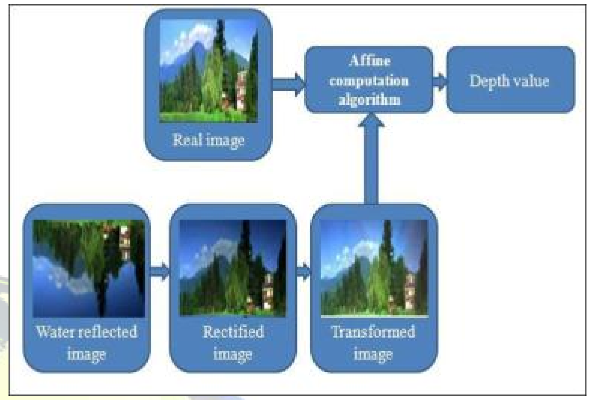


Figure 3.1: Block Diagram using Affine Computation Algorithm

The appearance difference is caused by several aspects:

- Brightness decrease due to the absorption of light by the water;
- Water fluctuations and ripples,
- Some small objects (e.g., tree leaves) floating on the water.

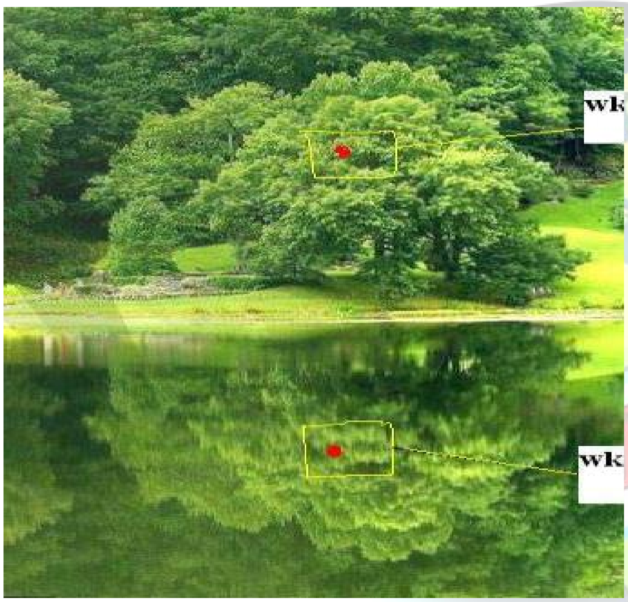
3.1 Image Rectification

- This appearance difference problem can cause serious depth errors.
- To overcome this problem, we propose an effective method to adapt the appearance of the mirror scene to the real scene after image rectification.

- After the adaptation, the appearance of the mirror scene is much closer to the real scene.

- Let (k, k1) be a symmetric image pair, where k is a point in the real scene and k1 is the mirror point.

- Also let ωk and ωk1 be two local windows of the same size centered at k and k1, respectively.



3.2 Image Transformation

For appearance adaptation, we regard each pair of corresponding pixels (i, j) in ωk and ωk1 as a symmetric image pair. Let I is the rectified image and I^t is the transformed image. Assume that I^t is a linear transform of I in ωk as

$$
\boxed{\begin{aligned} I_i^t &= a_k I_i + b_k \ \forall i \in \omega_{k'}, \\ I_i &= (r_i, g_i, b_i)^\top \end{aligned}}
$$

Determination of a_k and b_k

$$
a_k = \frac{\frac{1}{|\omega_k|}\sum_{(i,j)\in\omega_k\leftrightarrow\omega_{k'}} I_j^\top I_i - \mu_{k'}^\top \mu_k}{Tr(\Sigma_{k'})+\epsilon},
$$

$$
b_k = \mu_k - a_k \mu_{k'},
$$

3.3 Affine Computation Algorithm

This algorithm has 2 projective coordinates. Affine to projective coordinates. Projective to affine coordinates.

- **Affine variables** : x_p ,y_p and b.

- **Projective variables**: X1,X2,Z1 and Z2.

- **The algorithm consists of three stages:**

- Conversion of P from affine coordinate to projective coordinate;

- Computation of Q = kP in projective coordinate; and

- Conversion of Q from projective coordinate back to affine coordinate.

Computation of projective coordinate system(X1,X2,Z1 and Z2) for MSB=1

- Assign initial values for X1,X2,Z1 and Z2.(DWT COEFFICIENTS)

- Consider a point ‘P’ on the curve ‘C’ is xp=4; yp=3;

- //initial values of LD algorithm

- X1=1; Z1=0;

- X2=xp; Z2=1;

- Let T=Z1;
- Z1=(X1*Z2+X2*Z1)^2;
- X1=xp*Z1+X1*X2*T*Z2;
- T=X2;
- Z2=T^2*Z2^2;
- b=1;//constant integer
- X2=X2^4+b*Z2^4;

Computation of projective coordinate system(X1,X2,Z1 and Z2) for MSB=0

- Assign initial values for X1,X2,Z1 and Z2.
- Consider a point 'P' on the curve 'C' is xp=4; yp=3;
- //initial values of LD algorithm
- X1=1; Z1=0;
- X2=xp; Z2=1;
- Let T=Z2;
- Z2=(X1*Z2+X2*Z1)^2;
- X2=xp*Z2+X1*X2*T*Z1;
- T=X1;
- X1=X1^4+b*Z1^4;
- Z1=T^2*Z1^2
- b=1;//constant integer

Figure 3.2: Test Images

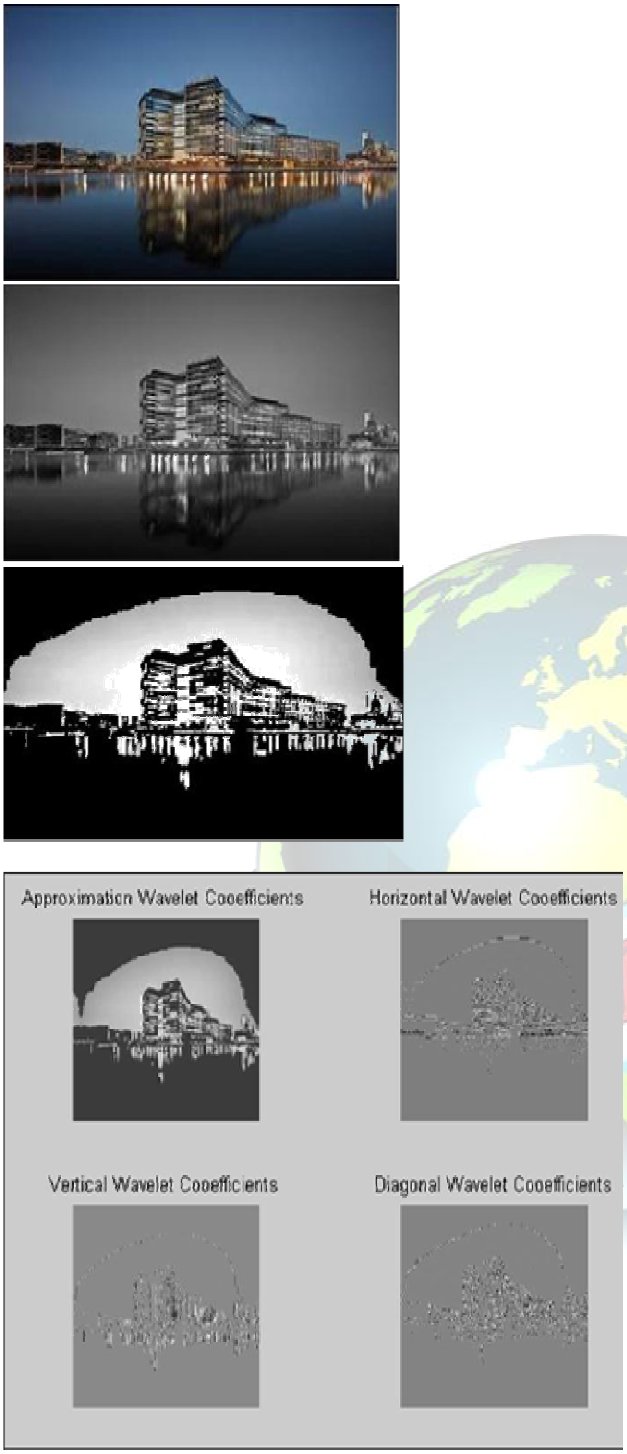


Figure 3.3: Result Analysis

4. CONCLUSION

In this paper, we have proposed a framework for a novel topic: depth from water reflection. Unlike other depth-from symmetry methods that deal with man-made objects, our approach reconstructs the depth of a scene where both natural and man-made objects may exist. Our algorithm first rectifies the image with detected symmetric keypoints to satisfy the scanline condition for stereo matching. It then applies appearance adaptation to the rectified image to reduce the appearance difference between the real scene and the mirror scene. Finally, dense stereo algorithm especially designed for this kind of symmetric scene is carried out to obtain the scene depth. Future work includes the combination of image parsing and depth from water reflection to improve scene understanding and depth reconstruction.

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