Three Dimensional Information Extraction of Buildings Using Shadow From A Single Image

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Abstract:
The three dimensional information of buildings is an important issue in urban monitoring, planning, management and various economic activities, and as a result of the tremendous development in the devices and remote sensing sensors, there is a need to obtain information about geographical locations with less cost, therefore the goal of this research is to extract the three dimensional information of buildings using shadow analysis appears in the 2D image and solving for the slope of view for this shadow without the need for additional data (another overlapping image or digital elevation model).

Keywords: 3D, 2D images, shadow analysis.

استخلاص معلومات ثلاثية الأبعاد لبنايات باستخدام الظل لصورة منفردة

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الخلاصة
أن المعلومات الثلاثية الأبعاد للمباني تعتبر مسالة مهمة في المناطق الحضرية من ناحية الرصد والتخطيط والإدارة والأنشطة الاقتصادية المختلفة، ونتيجة للتطور الهائل في أجهزة ومتحسسات الاستشعار عن بعد، هناك حاجة للحصول على معلومات حول المواقع الجغرافية مع اقل تكلفة، وبالتالي فان هدف هذا البحث هو استخراج المعلومات الثلاثية الأبعاد للمباني باستخدام تحليل الظل الذي يظهر في الصورة ثنائية الأبعاد وحل زاوية ميل هذا الظل ودون الحاجة إلى بيانات إضافية (صورة أخرى متداخلة أو النماذج الرقمية للارتفاعات).

الكلمات المفتاحية: ثلاثي الابعاد, صورة ثنائية الابعاد, تحليل الظل.

1. Introduction

3D reconstruction of buildings has been an active research topic in computer vision in recent years. 3D reconstruction of buildings from aerial images is becoming of increasing practical importance [1]. Traditional applications are those of cartography and photo interpretation. Newer applications include urban planning, construction, environment, communication, transportation, energy and property management, tourism, and virtual tours of cities [2]. Extraction of man-made objects from images has been studied by many researchers. In order to reconstruct accurate 3D

building structures most of previous approaches try to assume 3D information obtained by LIDAR or stereo analysis [3]. The single image of a scene is insufficient to compute a 3D reconstruction. The most obvious way to obtain 3D structure is therefore to consider stereo images. An alternative to use single image for building construction, considering with shadow constrains which help to extract the height of the buildings [4]. This paper presents a method for extraction the three dimension buildings height scene where shadows are present. This method is very simple for modeling and visualization of buildings. Our goal is to construct accurate 3D model by using one image measurements. In this circumstance, we try to find the height of buildings by solving for the slope of view for the shadow appears in the 2D image. The problem of computing the 3D building for aerial image of University of Technology had been used. In our case, the sun angle is unknown; we take the advantage of information about one building height or more, and with helping of this building shadow, the angle of shadow scene view could be calculated.

2. Assumptions

Such reconstruction of geometry relation bases on presumptions as followed:

1- Flat terrain
2- Upright building
3- No surrounding large-area water body
4- Normal weather condition

Condition 1 and 2 mean that shadow is directly projected on horizontal surface. As water body and shadow have similar characteristic, the existence water area can produce false classify and affected the buildings shadow [5].

3. Extract Building Outlines

Because of extraction buildings only from shadow, the criteria to separate buildings from other objects must be geometric ones. Based on general knowledge about buildings, which used size, and shape characteristics to classify buildings from other objects [6]. Due to the fact that buildings are man-made objects for accommodating human beings or objects, it should have enough height and size. The grey scale image gradient magnitude can be used to extract building outlines. The width and length of the buildings could be extracted easily by using edge detection technique [7].

4. 3D Building Reconstruction

Buildings are man-made objects with variety of shape and roof type. Also the texture, illumination, sun angle etc in an image made the extraction not difficult [8]. To represent the buildings height, a simplified model had been used. Most building extraction approaches assume that buildings have rectilinear shapes with flat roof. However, simple flat model has unlimited applications [9]. The height of the building depends on the shadow of building and the angle of shadow of this building on the image. The height of building of certain angle of shadow is expressed by the following simple formula:

$H = L / \tan(\alpha)$

Where, H = The height of building.
L = Horizontal length on the ground of building's shadow.
α =Angle of view of the building shadow.

The shadow which appears on the image will be varied in lengths according to the difference of buildings height. From the image the length of shadow could be measured easily. So, if we have a height of one building or more, we can simply determine the angle of view for the image using the shadow of this building, and by using this angle which is the same for all buildings in the image, it can be easily to determine the height of all buildings in the image, taken into consideration all assumption had been previously discussed. Fig.1. shows the expected types of shadow according to the sun moving all over a day.

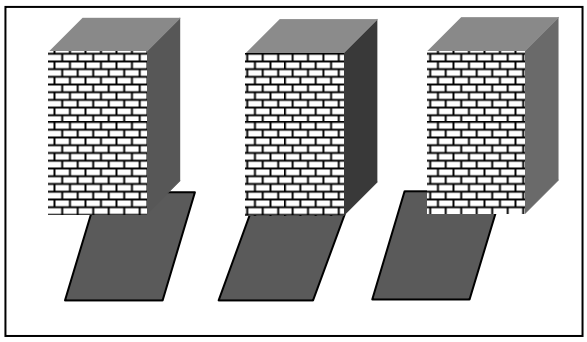

Figure 1- Different Available Shadows For A Building, At Sun Rise, At Noon And At Sun Set [10].

5. Experimental Work

To examine the accuracy of 3D reconstruction by using shadow, the simple formula will be applied to calculate building's height. In this study the example had been carried out in the University of Technology .As shown in Fig.3. the buildings in this example vary in the height, so the shadow will be varied and easily detected. First we have a building height, and by measuring the shadow, the angle of view shadow scene could be determined. Table 1

shows the results of different (6) buildings, table 1 shows good results which had been obtained by using this method. In this type of image we have no idea about the time and date of taking this image. In this case the height of the main building in had been known, and with the help of shadow length, the slope angle of shadow view could be calculated. For example, in our study the height of the six buildings (H) had been measured, and the length of shadow (L) for these buildings could be measured easily from the image. So, we can determine the angle of view for the image (α) as shown in Fig.2 using the simple formula:

$\tan(\alpha) = L / H$

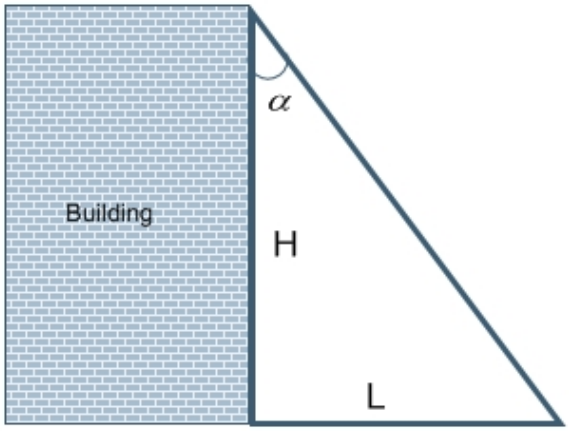

Figure 2- The Angle Of View For The Image (α).

For example, by using the measured height (H) and the length of shadow (L) of building (1), the angle of view for the image (α) is determined by:

$\tan(\alpha) = 27.156 / 19$

$\tan(\alpha) = 1.4292$

$\alpha = \tan^{-1} 1.4292$

$\alpha = 55° 1' 11''$

And by using this angle which is the same for all buildings in the image, it can be easily to determine the calculated height of all buildings in the image using the same formula:

$H = L / \tan(\alpha)$

For example, the calculated height of building (2) is determined by:

$H = 23.820 / 1.4292$

$H = 16.665$ m

So a comparison, between the true height of buildings and calculated height from the procedure had been made.

Figure 3- The Image Of University Of Technology, And The Edge Detection For The Buildings.

Table 1- The Results For The Buildings In Figure 3

Building	Meas. Height (m)	Length of shadow (m)	Calc. Height (m)	Difference (m)	Error %
1	19	27.156	19	0	0
2	17	23.82	16.665	0.335	1.97
3	19	26.767	18.727	0.273	1.436
4	19	26.773	18.732	0.268	1.41
5	5	7.613	5.326	-0.326	6.52
6	8	10.792	7.55	0.45	5.625

6. Conclusions

This paper proposes an algorithm to estimate building height by shadow analysis appears in the 2D image. This technique has advantage over other approaches. It provides reliable results with uncomplicated calculation. It could be confirmed that the height of buildings generated by this study has quire an effective as

the basic data that can be used for construction control relating to
the three dimensions model construction. The algorithm is supposed to work on flat ground surface. The error range of the experiment results was between (1.410, 6.520 m). The algorithm proposed showed the feasibility of extracting 3D information from shadow analysis. The future work must be concentrated on automatic building extraction by using shadow.

7. References

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