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Master's Thesis

Real-time Intrinsic Image Decomposition using Reconstructed Indoor Scene for Dynamic Relighting

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Abstract

Real-time Intrinsic Image Decomposition using Reconstructed Indoor Scene for Dynamic Relighting

We present a first approach real time intrinsic image decomposition of indoor scene. Improvement of multiple view 3D reconstruction make image-based modeling available. However, shading included reconstructed texture restrict their utility. Therefore we present intrinsic image decomposition method to manipulate lighting using reconstructed model. Our methods aim at removing shading from the indoor scene reconstructed by commercial multi-view 3D reconstruction software. We apply inverse rendering to estimate reflectance relative to reconstructed geometry information. Relighting with image-based modeling using our method do not lose simplification of lighting. Real-time performance is obtained by applying Phong reflection model and Light Propagation Volume (LPV) used for real-time rendering. Ambient value for indirect lighting approximation is added based on the implementation to avail our method with the inaccuracy geometry. Our method approximates reflection light color using bilateral filter and acquires the high quality estimation by removing indirect lighting. Since we perform light source estimation based on reconstructed model, do not require special equipment to measure lighting condition.

Keywords: Intrinsic Image Decomposition, Inverse Rendering, Relighting, Real-time rendering

1. Introduction

3D reconstruction has been done using depth, camera or special hardware. But recently, the improvement of 3D reconstruction, 3D geometry can be reconstructed by multiple view image. Therefore, 3D reconstruction using multiple view images make commercial application software available without special hardware [1-4]. 3D reconstruction methods have improved accessibility to image-based modelling [5] and reduce the cost and effort for 3D modeling. However the utility of reconstructed models is restricted. The cause is the shading include in texture captured under fixed lighting. Usage of model with shading information is restricted in programs that often manipulate lighting condition, such as games and movies. Removing shading from image methods have been introduced to utilize the reconstructed model in program frequently change lighting condition. In the case of 3D reconstruction for an object, it is possible to position the object in a special device that manipulate the light condition for capture and minimize the effect of shading. However 3D reconstruction for environment is not possible, since there scale and fixed lighting fixtures.

Objects in the real world are recognized and captured by the interaction of reflectance and light. Assuming all surfaces in the scene has Lambertian surface, pixel color can be defined by the product of shading and reflectance. Therefore, estimating reflectance of object by removing shading from images is possible. Intrinsic image decomposition aim to separate material properties-reflectance component and shading component, and facilitates object recognition, image editing and lighting condition editing.

Intrinsic image decomposition is an ill-posed problem since we should estimate two unknowns based on given single image [6-9]. To solve ambiguity, several approaches require additional information. They require multiple view images taken under fixed lighting conditions [10-13], images taken under various lighting condition[14], and images with depth information [14-15].

Intrinsic image decomposition for entire space is studied only a small number, and which is also limited to outdoor [10-11]. In outdoor case, it is assumed that sun only exists the lighting condition is changed with the movement of the sun. Due to the assumption, the feature of light source unchanged and, the ambiguity of the intrinsic image decomposition. However, in indoor case, The lighting fixtures are fixed and it is difficult that changing the lighting condition by manipulating the light.

Most Intrinsic image decomposition methods take long computation time. Recently, real-time methods [17-19] presented, however, it is still a small number and do not consider geometry information. And most estimations are performed on a single image or object. A few methods presented about entire scene, which is limited to the outdoor [10-11] and do not provide realtime performance.

We introduce a first attempt to remove shading from the texture of the reconstructed indoor model in real-time. We use multiple-view images taken fixed lighting condition, and perform automatic 3D reconstruction using commercial software. Our method aims at unconstrained lighting control using reconstructed models of multi-view 3D reconstruction. Intrinsic image decomposition methods for image editing are not suitable for relighting based on image-based modeling, since they perform decomposition regardless of geometry information. Our method estimates reflectance relative to degree of geometry reconstruction for relighting and keeps the benefit of image-based rendering, simplification of lighting. We do this by using light source estimation and inverse rendering. Since we perform light source estimation based on reconstructed model, we do not require special hardware to approximate lighting condition. Estimated light source is regarded as point light to handle the indoor scene that has various lighting fixtures that is hard to define the feature.

We achieve real-time performance by applying real-time rendering method for inverse rendering and dividing lighting as direct lighting and indirect lighting. Phong reflection model [20] is used for direct lighting and Light Propagation Volume (LPV) [21] is used for indirect lighting. All of the estimated light source is regarded as light source for direct lighting, However threshold is used for indirect lighting to avoid useless computation. And considering the imperfect reconstruction using commercial software without special hardware, ambient value that adjust brightness is applied. Indirect lighting require the reflection light color that present the color of surface where the interaction occur. We perform texture flatten using bilateral filter to avoid iteration for estimating reflection light color.

2. Related Work

Intrinsic image decomposition we proposed is related to the inverse rendering that estimate the unknown information using rendering equation and intrinsic image decomposition for image editing. Our method aim to enable manipulating the lighting condition using image based model without high cost light computation due to the reality from photographs, so our method more similar with the inverse rendering that use geometry information. Since the intrinsic image decomposition for image editing do not consider the rendering, and aim to perfect separation of reflectance from images to edit the colors and recognize objects.

2.1 Inverse Rendering

Inverse rendering approaches render backward from photographs to scene components such as geometry, reflectance and lighting to estimate unknown data. Therefore, reflectance can be estimated when the geometry and lighting information is exist. Our method perform intrinsic image decomposition related to the degree of geometry reconstruction. Therefore, inverse rendering, estimate the reflectance based on geometry and lighting is close to our method.

Estimating reflectance using inverse rendering requires geometry and lighting information. Improvement of 3D reconstruction make estimating geometry information possible. Depth camera[18-19], IR sensor [22], multiple images or other special hardware used to reconstruct geometry. Lighting is measured through the environment map taken with reflective sphere [10-11]. Some approaches manipulate lighting conditions during taking pictures[13-14].

Real-time intrinsic image methods using inverse rendering are introduced based on Shape from Shading (SfS) [23] that recovers geometry and reflectance using shading information. SfS is estimate the shading using depth information, and refine the shading information by iteration. Real-time methods based on SfS [18-19] use the video stream as input data and refer previous frame information to enhance accuracy. They are only limited to object not full scene and require depth camera.

Some approaches manipulate the light and take pictures from different lighting condition [13-14]. However this approaches is difficult to utilize to entire scene. In outdoor case, taking picture under the various lighting condition by the time passes is possible, however that is very time consuming and can not be adopted for indoor scene.

Intrinsic image decomposition methods for space [10-11] are limited to outdoor scene. They assume sun is the only light source and other lightings come from sky light, and use reflective sphere to measure the lighting condition. And they take long computation time.

2.2 Intrinsic Image Decomposition

Many methods for image editing were presented to decompose images into reflectance and shading without using geometry reconstruction. Though lots of approaches are proposed, intrinsic image decomposition for image editing can not be adopted to image based model. Since they can not preserve the simplification of lighting, the benefit of image based modeling from photographs.

The Retinex algorithm classifies edges of grayscale image into shading or reflectance based on the assumption that shading has gradual and reflectance has sharp variation. Many approaches based on this assumption [24-25] were presented, but Retinex based algorithm occurs error where shading dramatically change like hard shadow. Methods using Assumption that neighboring pixels with similar chromaticity have the same reflectance is presented [8, 26]. Other approaches such as clustering [27] and additional optimization [9] to improve the accuracy were attempted.

Despite of many approach, intrinsic image decomposition remains ill-pose problem. To solve this ambiguous, many methods use various additional information such as images taken under different light condition [12-13], depth information [14-16], user assisted [9] and video stream [17].

Intrinsic image decomposition is almost require long computation time, since they adopt iteration to improve the accuracy. Generally, as the number of iteration is increase, the accuracy of the intrinsic image decomposition is increases, however the performance decrease.

Real-time intrinsic image decomposition for image editing method [17] was proposed based on the video stream. This method also need iteration to improve the quality, even can obtained real-time solution using GPU optimization. And this approaches use the feature of video stream, by using the information that the previous frames have, which complement the lack of informations and some case computation can be replaced by using result of the previous frames. However, most intrinsic image decomposition methods still require long computation time.

3. Algorithm

In this paper, we present a first approach to real time intrinsic image decomposition of indoor scene. For our purpose, we obtain geometry and texture by 3D reconstruction using multiple view images. Images are taken from different viewpoints under fixed lighting condition. In this process, the model includes light fixtures should be reconstructed. Since reflectance is estimated by dividing the input texture by shading, we approximate shading using light source information and reconstructed geometry. The light source is estimated based on reconstructed model and we can obtain the color and position information.

We divide the lighting into direct lighting and indirect lighting to obtain high performance. Direct light can be calculate directly using geometry information and result of light source estimation. However, indirect lighting is occurred by interaction of light and object's multiple reflection and lighting color is affected by reflection point. Therefore, we should consider reflectance of reflection point. However, our algorithm aim to estimate the reflectance of object. The reflection light color can not be obtain directly. Generally, indirect lighting require iteration to calculate the effect, which drop down the performance. Therefore, it is not suitable for real time rendering. We apply the filtering on the reconstructed model texture and approximate the object's reflectance and adopt real time rendering method that do not perform iteration.

The result of direct lighting and indirect lighting is combined and we estimate the reflectance by dividing texture into lighting estimation result. The method we present is aim to diffuse objects and, do not consider the specular reflectance. Therefore, we assume all materials in the scene have Lambertian surface and do not consider shadows. Fig. 1 shows overview of our algorithm.

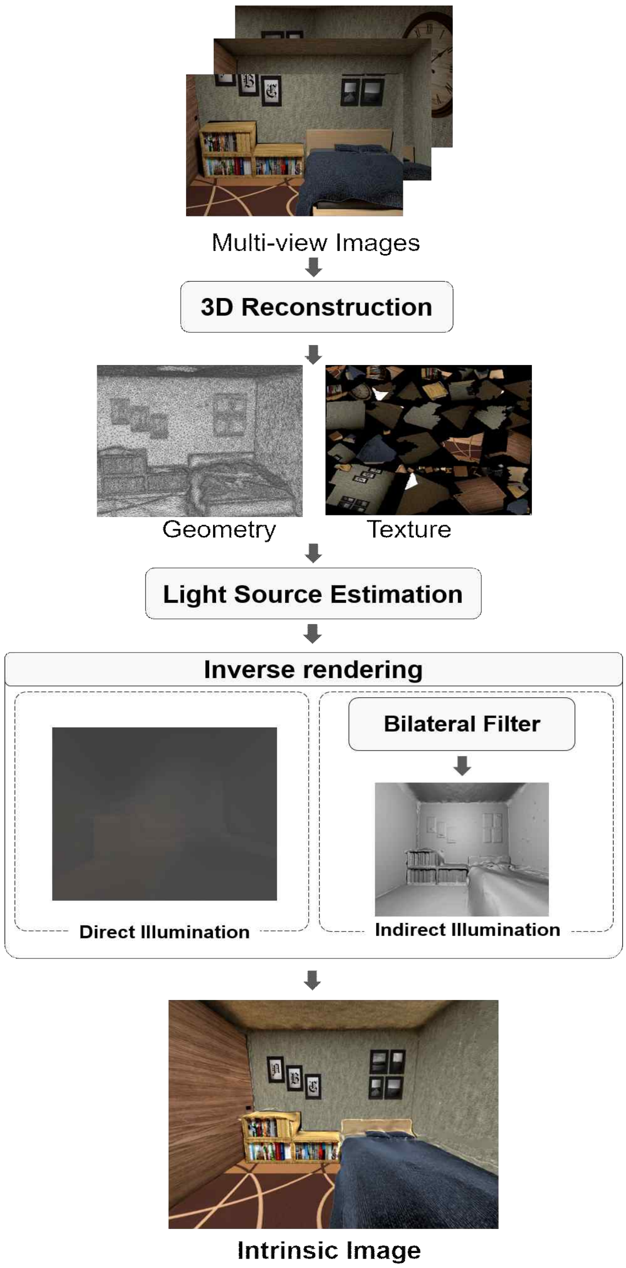

Fig. 1 Overview of
the intrinsic image process proposed

4. Data Organization

4.1 3D Reconstruction using multiple view images

We aim to intrinsic image decomposition about indoor space 3D model that is reconstructed without special device such as depth camera. We use multiple view images and reconstruct the entire indoor scene using commercial software. Our method can operate for 3D reconstruction indoor space model and the light fixture emit lighting must be reconstructed.

3D reconstruction using multiple view image can eliminate some specular effect due to the process combine the image process. Even though out method do not consider the specular, due to the 3D reconstruction using multiple view image process, some specular effect is removed. And the reconstructed model is more suitable to operate our method.

4.2 Light source Estimation

Our method even do not require the hardware estimate the lighting condition such as the sphere ball to capture environmental map. And unlike the outdoor, lighting condition is changed according by time passes, lighting fixtures in indoor scene is fixed and hard to manipulate the lighting. Therefore, We adopt light source estimation based on 3D model texture. Our method target the entire indoor model, so the light fixture that emit the light can be reconstruct when we perform 3D reconstruction. Our method is available when the model reconstructed entire scene include the light fixtures. The position information in the 3D model estimated light source can be obtained using texture coordinate and vertex information.

Indoor environment have various light fixtures with different characters, we cannot define the feature of light source. So we assume the light source estimation result as numerous point light. As the result, We can obtain point light's color and position information. To enhance accuracy, before the light source estimation LDR (Low Dynamic Rage) texture is converted to HDR (High Dynamici Rage) texture. Figure 2. represent the result of light source estimation and 3D reconstructed model using multiple view images. the red dot represent the estimated point light.

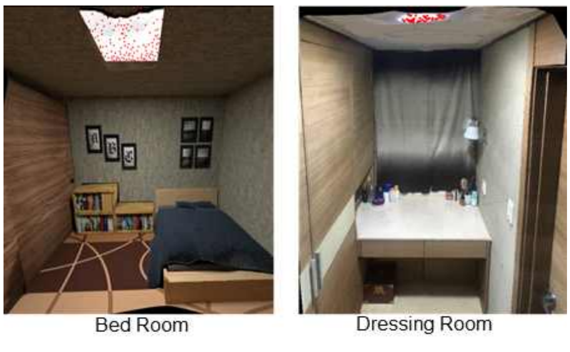

Fig 2. The result of 3D reconstruction and light source estimation. the red dot represent the estimated light source.

5. Image Model

We perform shading estimation using reconstructed model and estimated light source to estimation reflectance. Pixel color is defined as the multiple of reflectance and shading, result of lighting. We estimate just light source however, the shading is based on multiple interaction of lighting and the objects. To make the problem simply, we separate the lighting as direct lighting and indirect lighting like other real time rendering approach. Direct lighting is calculated using the light source and geometry information. However, Indirect lighting is more complex problem. We should consider the reflection occur the surface of the objects, which means calculating indirect lighting require the reflectance information. The reflectance is the goal of intrinsic image decomposition. Therefore, to estimate the accurate reflection light color computing lighting and estimating the reflectance, which take long computation time, is performed repeatedly more than just calculating the indirect lighting. We focus on the performance than the quality and adopt real time rendering method that consider one bounce indirect lighting and propagate the one bounced result and use filtered texture.

5.1 Realtime Performance

To achieve real time performance, we divide the lighting into direct lighting and indirect lighting and adopt the realtime rendering method. Phong reflection model is used to compute direct lighting. For indirect lighting, LPV do not require multiple iteration is adopted. Following is our image formation model.

$$I_p = R \sum_{i \in pl}^{i} (\cos\theta L_{total}) \qquad (L_{total} = L_{direct} + L_{\in direct})$$

$$= R \left\{ \sum_{i \in pl}^{i} (l \bullet n) L_{direct} att(d) + \sum_{i \in pl}^{i} \cos\theta L_{\in direct} \right\}$$

$$= R \left\{ \sum_{i \in pl}^{i} (l \bullet n) L_{direct} att(d) + LPV \right\} \tag{1}$$

I_p is the pixel at given image and R is the reflectance of the object. Where L_{direct} and $L_{indirect}$ are direct and indirect lighting, θ is the incidence angle. l is the direction vector from the point on the surface toward each light source, and n is the normal at this point on the surface. $att(d)$ represents the attenuation of light according to distance d.

5.2 Inaccurate Reconstruction

The quality of multiple view images reconstruction without special hardware is worse compare to using special hardware such as depth camera. Therefore, some geometry informations are not reconstructed. Inaccuracies and missing data of Reconstruct geometry make indirect lighting approximation inaccurate. Inaccurate missing data make the lighting darker, which means reflectance is estimated brighter. Fig. 3 shows the bad intrinsic image decomposition result because of the missing data.

We use ambient value used in Phong reflection model to overcome the limitation of reconstruction. Ambient value is applied to approxiate the indirect lighting is applied with LPV in the image model. Below shows the modified image model.

$$I_p = R\left\{\sum_{i \in pl}^{i}(l \bullet n)L_{direct}att(d) + LPV + ambient\right\} \quad (2)$$

We perform an implementation to estimate the usability of ambient value and the implementation confirmed that indirect lighting approximation using LPV with ambient shows better quality. Fig. 2 illustrates our implementation result involve the missing data from floor make the inaccurate reflectance estimation result.

The ambient value is can be used to manipulate the brightness of entire lighting. However, using the high ambient value, the lighting effect is too bright, make the reflectance darker and estimation result shows worse quality.

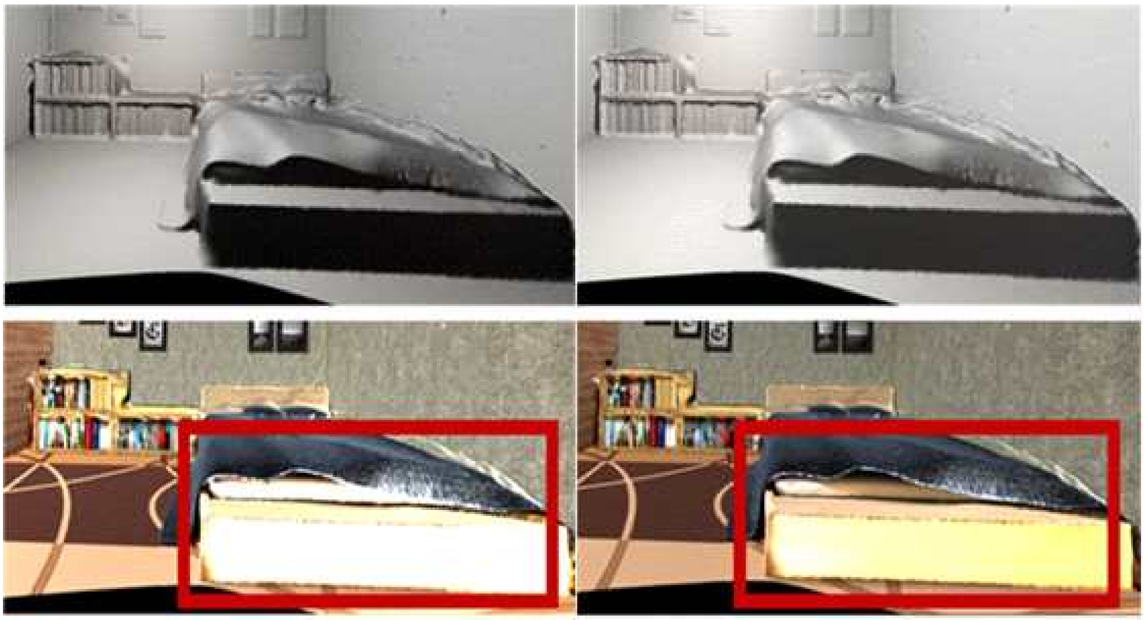

Fig. 3 Results of intrinsic image decomposition and shading approximation using LPV (left) and using LPV with ambient (Right) to approximate indirect lighting.

Ambient value just manipulate the brightness of lighting, therefore, cannot represent the effect of reflection light. Ambient value cannot replace the LPV represent the indirect lighting involve the reflection lighting color and effect. We perform an implementation to compare the estimation result of image model using just ambient value and using ambient value and LPV together.

Fig. 3 shows the results of the reflectance estimation based on indirect lighting approximation using ambient and LPV with ambient. Shading approximation using ambient cannot represent reflection lighting. However, shading Approximation based on LPV with ambient approximate reflection light with color and removes shading from the drawer. Fig.4. shows the result of implementation using ambient and LPV. Shading near by the drawer shows yellow color and the intrinsic result of wall paper is more flatten due to eliminating the shading color from texture.

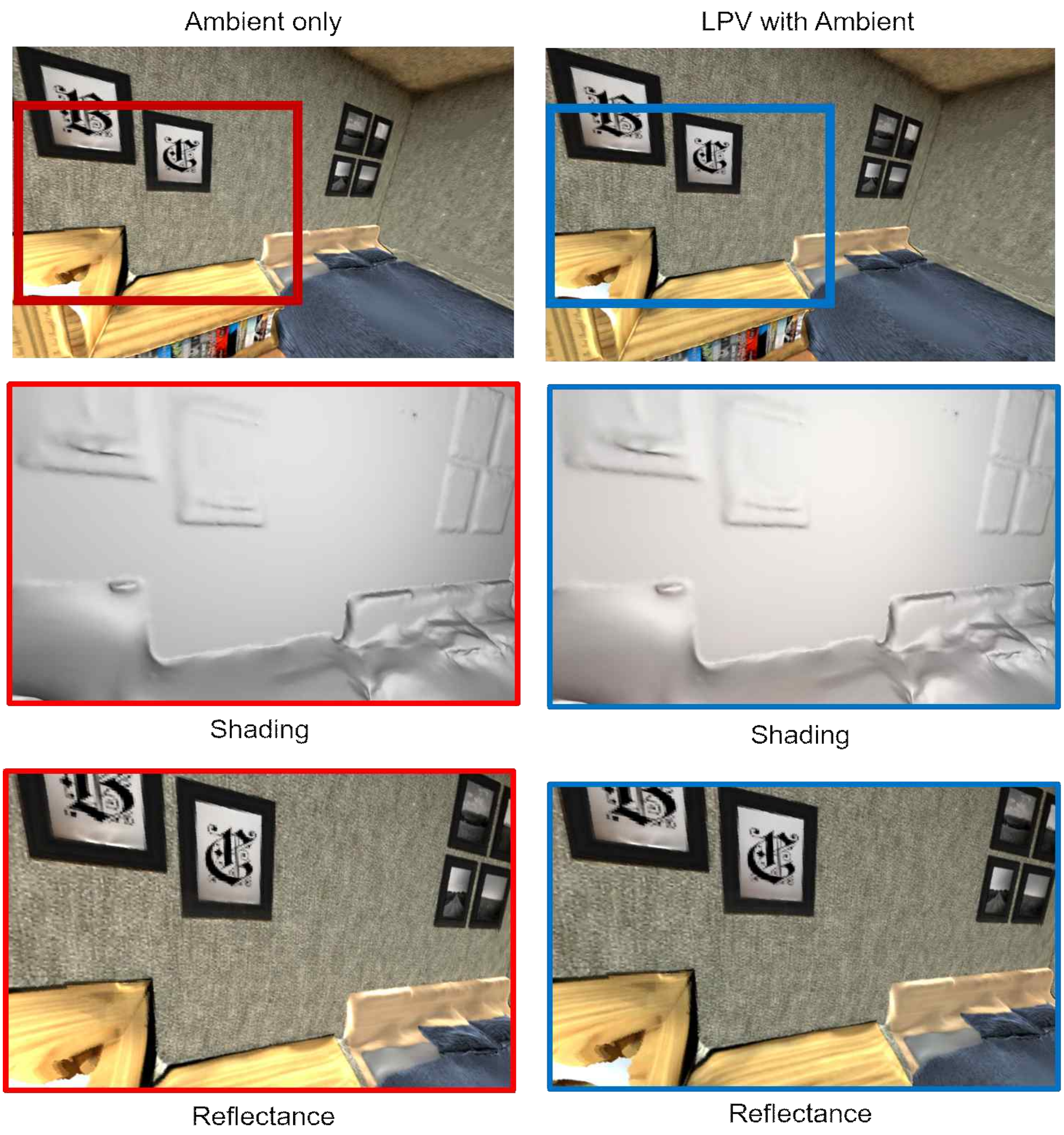

Fig. 4 Results of intrinsic image decomposition using just ambient (left) and using LPV and ambient (right) together to approximate indirect lighting.

6. Texture Flatten

Indirect lighting is the multiple interaction of light that reflected the objects surface and other objects surface. Reflection light require the reflectance of objects to represent the light color. However, the purpose of intrinsic image decomposition is estimating the reflectance, represent the indirect lighting include the reflectied light color is complex.

6.1 Problem of Approximating Reflection light color

Some approach[] do not consider the color of reflection light or redefine the reflection light using iteration. estimating and redefining the reflectance approach is used for inverse rendering and intrinsic image decomposition for image editing both. In the first iteration, shading include the reflectance is eliminate form texture, according the number of iteration shading value is redefined and the genuine shading can be get rid of the texture. Increasing the number of iteration usually makes the quality better however, makes the performance slow. Even the computing the indirect lighting without estimate the reflectance take almost computation time, therefore adopting iteration at inverse rendering cause the serious performance degradation. In this paper, we apply texture filtering to estimate the reflection light color to prevent the performance degradation.

6.2 Texture filtering to approximate reflection light color

Texture flatten is inspired by Retinex algorithm. Retinex algorithm studied for intrinsic image decomposition for image editing is based on the assumption that the changing of reflectance has sharp variation but the changing of shading occurred by lighting is gradual. Inspired the assumption, we adopt Bilateral Filter[] to estimate the reflection light color. Bilateral Filter is a de-noise method, which preserve the edge of image. The changing of reflectance shows the sharp variation can be considered as the edge, and the changing of shading is blurred without preserve due to their smooth changing. Retinex based algorithm do not work properly where the shading change dramatically such as hard shadow. It is not problematic since, we do not consider the shadow for estimating reflectance.

Texture flatten is applied to reconstructed texture, before computing indirect lighting. Pixel color and geometry information is used to compute bilateral filter. Bilateral filtering should load more than one element to preserve the edge, therefore performance degradation arise. We make the operation computed by GPU to improve the performance. Since our purpose is estimating the reflectance based on geometry information, flatten texture is just used to estimate the reflection light color.

7. Inverse Rendering

Inverse rendering is a method estimate an unknown data based on image formation model and known data. In our case, reflectance is unknown data and geometry is known by 3D reconstruction. And lighting can be estimated using 3D reconstruction, light source information, texture and image formation model. The method we proposed use automatic 3D reconstruction software using multiple view images taken under fixed lighting condition. If the geometry and lighting is obtained, reflectance can be estimated dividing into shading.

7.1 Inverse Rendering for Direct lighting

We estimate the position and color information of light source by light source estimation [29] that estimate area light as point light. Each lighting fixture has their own feature, and we cannot define that, therefore we assume the estimated light as point light. Light source estimation result a large number of point, since the lighting fixtures form real-world have area. All of the estimated point lights are used to compute the direct light. Light attenuation real world light have can not be estimated form the light source estimation. Therefore, we should manipulate the attenuate value by heuristic.

7.2 Inverse rendering for indirect lighting

Flatten texture and estimated light source is used to compute indirect lighting. We adopt LPV at our image model and prevent performance degradation by iteration. LPV generate reflectance shadow maps (RSM) [30] approximate the reflection light color and position. RSM project the scene from light position and assume the surface projected that light camera as reflection point where the first reflection light is occurred by lighting fixture. RSM is generated from light fixture, since LPV only consider the first reflection and propagate the effect to adjacent space. At that time reflection light color is estimated using texture correspond to reflected point.

As a result of light source estimation [29], area lights are estimated a large number of point lights and RSMs are generated for each point light to compute LPV. Computing direct lighting using dense point light can improve the shading result, however in case of indirect light computing using LPV is different. RSMs for approximating reflection light generated by adjacent point light have the same information about reflection light, since the projection result is similar. Thus using all of them does not affect the quality of lighting approximation and just takes long computation time. Therefore, we adopt threshold to prevent generate RSM of adjacent point lights. Below demonstrate the complete inverse rendering equation. pl' is light source used to generate RSM.

$$R = \frac{I_p}{\left\{ \sum_{i \in pl}^{i} (l \cdot n) L_{direct} att(d) + \sum_{j \in pl'}^{j} (LPV + ambient) \right\}} \quad (3)$$

The final shading is computed by combining indirect lighting and direct lighting. Reflectance is obtained by dividing texture into shading result. The result does not show complete separation of reflectance, because the lighting is computed using the geometry information. The genuine texture, texture filter is not applied, is used for dividing to preserve the small detail the advantage of image based modeling.

8. Results

We implemented our method in a rendered scene and a real-world scene. The rendered scene is designed to only occur diffuse reflection to and Mitsuba renderer[31] is used to make bedroom scene. We used 70~80 multiple view images to reconstruct the rendered scene. The real world data, dressing room scene, is reconstructed using 70~80 images captured by general camera of IPhone 6S. Images taken under fixed lighting condition, and the indoor scene model that includes lighting fixtures is reconstructed. We used Autodestk Recap (http://recap360.autodesk.com), commercial software, for automatic multiple -view 3D reconstruction and acquired proxy geometry and an atlas texture.

8.1 Performance

We performed our method on Intel(R) Core(TM) i7-5960X CPU, GeForce GTX 1080 Ti GPU. The rendered scene (Fig. 5) took computation time for bilateral filter computation time 6.31ms, inverse rendering 29.75ms and total 36.06ms. The real-world data (Fig. 6) took bilateral filter computation time 6.52ms inverse rendering 29.36 and total computation time 34.91ms. We confirmed that our method shows real-time computation time based on implementation.

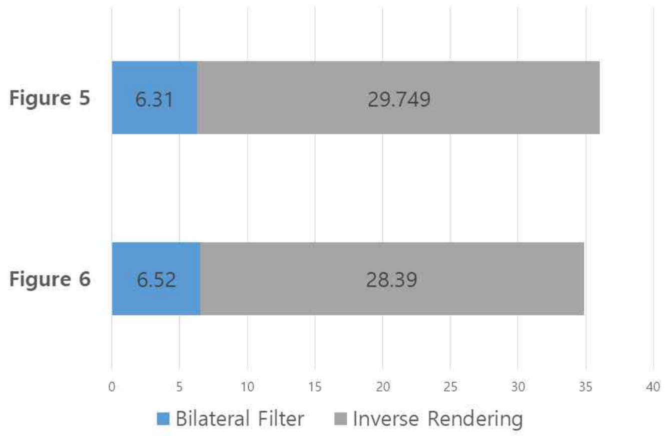

Table 1. The implementations computation time(ms) for bilateral filter and inverse rendering.

8.2 Implementation in Rendered Scene

We implement our method in the rendered scene that designed all objects have Lambertian reflectance. Fig. 5 shows reconstruction result, shading approximation and reflectance estimation.

We can verify the quality of our method in the area where the variance of shading is large (yellow box). In case of the wall close to drawer (redbox), the shading containing the color of indirect lighting is removed from the wallpaper. As the result, we can ensure that indirect lighting approximation using bilateral filter improves the quality of estimation. However, the inaccuracies of reconstruction and lighting approximation without considering the characteristics of light sources make inaccuracies of estimation at some area. Bed (blue box) shows the inaccuracy of estimation arose from wrong reconstruction. Ceiling and wall estimated different color despite they have same reflectance (green box). The cause is wrong shading approximation without considering the features of light.

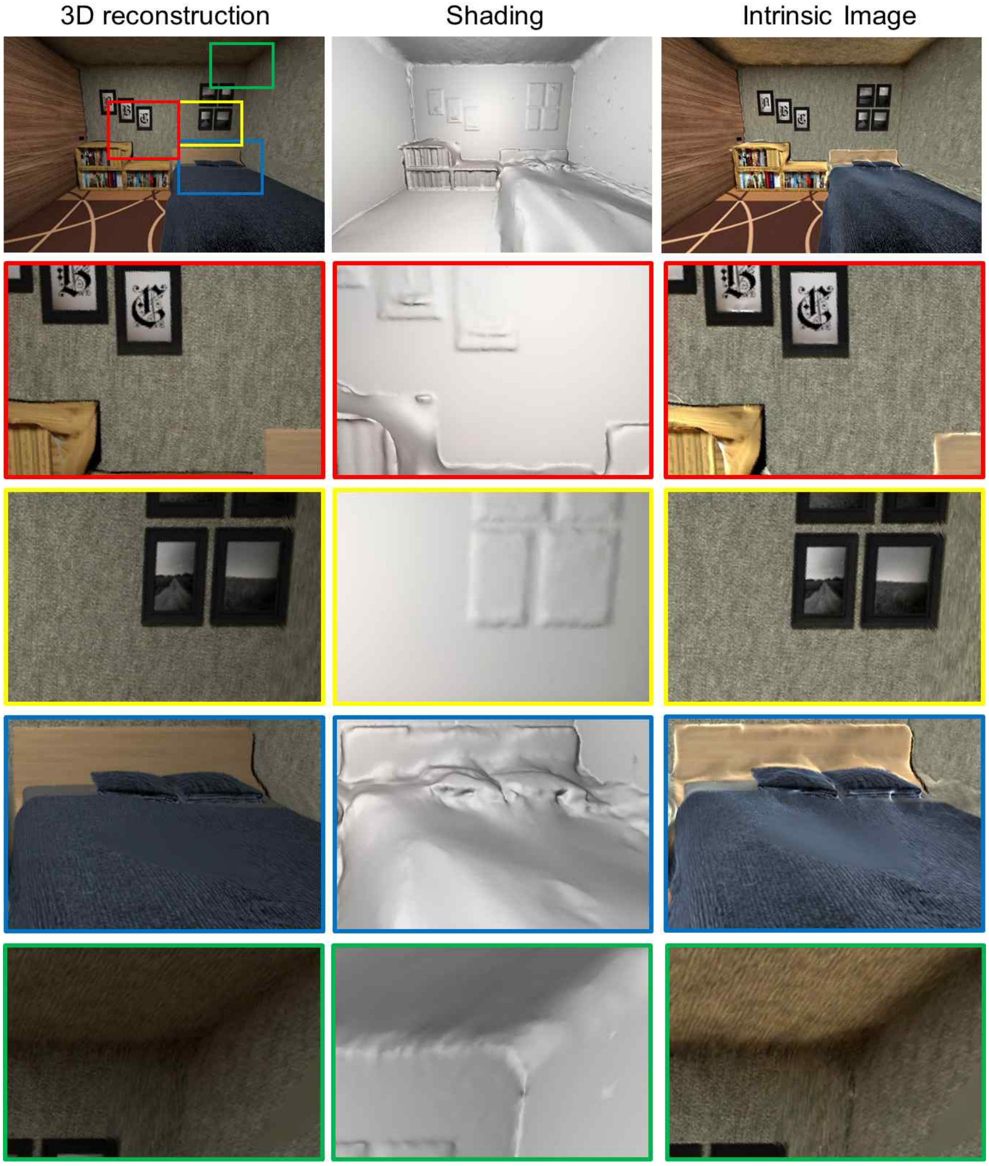

Fig. 5 Results of intrinsic image decomposition using virtual environment designed to cause diffuse reflection only. From left, 3D reconstruction result, shading approximation and intrinsic image results are shown.

8.3 Implementation in Real−world Scene

We performed intrinsic image decomposition using real world data and demonstrate our method can be applied in real-world.

Fig. 6 shows reconstruction result, shading approximation and reflectance estimation. We can see the quality of our method in the area where the variance of shading is large (red box). Removing Shading by indirect lighting operated in dressing table (yellow box) improved quality of estimation. However, similar to Fig. 4, inaccurate estimation is performed by the inaccuracies of geometry, which is shown from switch (blue box). Unlike our assumption, the real world has various reflective properties, which led inaccurate decomposition. We can see that specular reflection from the dressing table (green box).

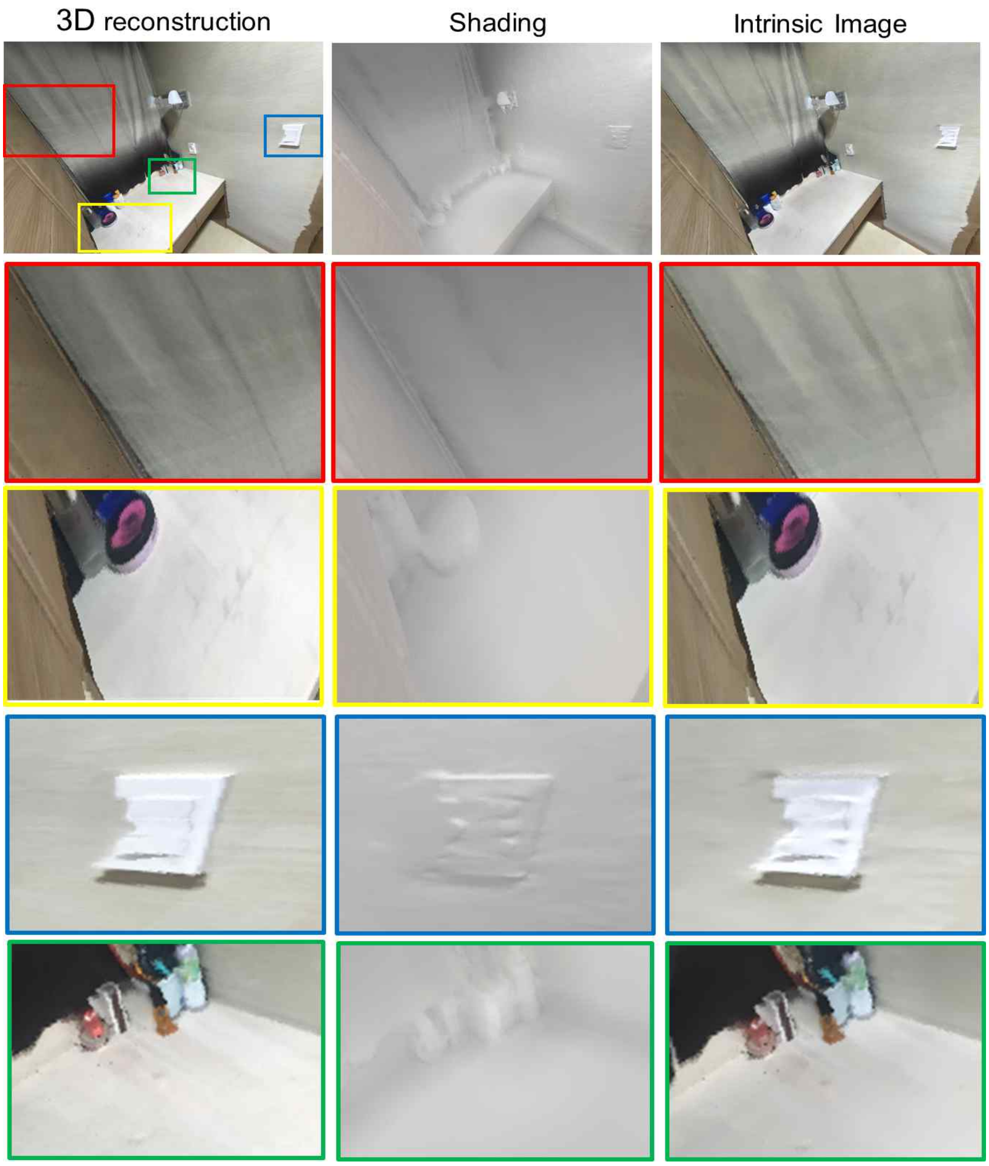

Fig. 6 Results of intrinsic image decomposition using real world data. From left, 3D reconstruction result, shading approximation and intrinsic image results are shown

9. Conclusion

We proposed an intrinsic image decomposition method that enables to manipulate lighting condition using reconstructed model by removing shading. Our method performed reflectance estimation relative to geometry, which did not lose simplification of lighting, benefit of image-base rendering.

Our method aim to reconstructed indoor space model using commercial soft ware without special hardware. we should consider the indoor space's feature that hard to manipulate the light condition to estimate the lighting condition. Therefore, we adopt light source estimation based on reconstructed model texture without hardware such as sphere ball to capture environment map. And we can estimate the color of light source since we use the texture for estimation. Our method is easily utilized reconstructed model by multi view images taken fixed lighting condition for relighting. All estimated light source is regarded as point light to mimic various lighting fixtures characters.

We achieve real time performance using real time rendering techniques and dividing lighting as direct lighting and indirect lighting for inverse rendering. Phong reflectance model and LPV is adopted to image model, and we added ambient in our image formation model based on the implementation, and obtain better quality of estimating reflectance using inaccurate geometry using automatic 3D reconstruction. All of the point light is used for computing direct lighting and computing indirect light use portion of point light to void computation about adjacent light source. Bilateral filter is applied to texture to approximate reflection light color and avoid iteration.

We implemented our method at rendered scene only diffuse reflection occur and real word scene captured using commercial camera and confirmed reflectance was estimated considering the geometry reconstruction. And even though we consider diffuse reflection only thanks to 3D reconstruction using multiple view images, some specular effect is remove.

10. Limitations and Future Work

Indirect lighting approximation generated unnecessary RSMs and overhead caused, therefore, user should intervene to adjust the threshold. It can be solved by merging adjacent point lighting using light position information and make one RSMs for a light fixture.

we adopted texture flatten to estimate reflection light color. It is meaningful that can eliminate the effect of indirect involve reflection light color. However model texture has shading, which makes reflection light color brighter or darker. It can be overcome some iteration. However the method we proposed choose performance rather than quality for real-time estimation.

Our estimation assumed all objects has diffuse surface, therefore the specular reflectance can not be estimated. We could overcome the limitation using multiple view reconstruction. Since the 3D reconstruction replace the missing data caused specular effect using multiple view images. And we did not consider the shadow since, the shadow does not have information to estimate the reflectance where shadow is drawn. It can be overcome by using the adjacent pixel to fill the spot where the shadow exist.

We can not measure the quality of method because of the lack of reference. In real world, we can not extract the reflectance of object, therefore, some reference to measure the quality of intrinsic image decomposition is presented. However the references are limited to intrinsic image decomposition for image editing that do not consider the geometry information, which is not available to our method.

Estimation inaccuracies caused by result of light estimation that regard lights as point lights. This limitation can be resolved by using use-assistance input about light characteristics. Our method was not work automatically since the LPV, light power and attenuation for lighting require adjustment by heuristic. The shading computation can be replace by other method such as path tracing or virtual point lighting that guarantee better quality, however require long computation time. According the intrinsic image decomposition purpose, the method can be changed.

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논문요약

실내 환경 복원 모델을 이용한 동적 조명 적용을 위한 실시간 재질추정 기법

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3D 기하 복원 기술의 발전으로 다시점 이미지와 상용 프로그램을 이용한 영상 기반 모델링의 접근이 용이해졌다. 하지만 복원된 모델의 텍스처에 포함된 음영으로 영상 기반 모델의 사용은 한정되어 있다. 따라서 우리는 복원된 모델을 이용한 동적인 조명 조작을 위한 재질추정 기법을 제안한다. 본 논문이 제안하는 기법은 실내 환경을 복원한 영상기반 모델을 목표로 하며, 영상 기반 모델은 다시점 이미지를 이용한 상용 프로그램으로 제작된다. 우리는 기하의 복원 정도에 비례한 재질 추정을 위하여 역렌더링 기법을 적용하여 본 논문이 제시하는 재질 추정을 수행한 모델은 영상 기반 모델의 장점인 조명 적용의 간략화를 잃지 않는다. 실시간 성능은 실시간 렌더링 기법인 퐁 반사 모델과 광전파볼륨을 적용하여 달성하였으며, 사용 프로그램을 이용해 복원한 기하의 불완전성을 고려하여 앰비언트 값이 간접조명 근사에 포함되었다. 간접조명 근사 시, 반사광 색상 근사를 위하여 양방향 필터가 적용되었으며, 간접 조명의 색상을 포함한 음영제거로 보다 높은 품질의 재질추정을 수행할 수 있었다. 본 논문이 제안하는 기법은 텍스처 기반의 광원추정으로 조명 측정을 위한 특수 장치를 요구하지 않는다.

주제어: 재질추정, 역렌더링, 재조명, 실시간 렌더링

(표지측면)

Real-time Intrinsic Image Decomposition using Reconstructed Indoor Scene for Dynamic Relighting

2019

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