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Technical Section

Automatic garment retexturing based on infrared information ☆

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ABSTRACT

This paper introduces a new automatic technique for garment retexturing using a single static image along with the depth and infrared information obtained using the Microsoft Kinect II as the RGB-D acquisition device. First, the garment is segmented out from the image using either the Breadth-First Search algorithm or the semi-automatic procedure provided by the GrabCut method. Then texture domain coordinates are computed for each pixel belonging to the garment using normalised 3D information. Afterwards, shading is applied to the new colours from the texture image. As the main contribution of the proposed method, the latter information is obtained based on extracting a linear map transforming the colour present on the infrared image to that of the RGB colour channels. One of the most important impacts of this strategy is that the resulting retexturing algorithm is colour-, pattern- and lighting-invariant. The experimental results show that it can be used to produce realistic representations, which is substantiated through implementing it under various experimentation scenarios, involving varying lighting intensities and directions. Successful results are accomplished also on video sequences, as well as on images of subjects taking different poses. Based on the Mean Opinion Score analysis conducted on many randomly chosen users, it has been shown to produce more realistic-looking results compared to the existing state-of-the-art methods suggested in the literature. From a wide perspective, the proposed method can be used for retexturing all sorts of segmented surfaces, although the focus of this study is on garment retexturing, and the investigation of the configurations is steered accordingly, since the experiments target an application in the context of virtual fitting rooms.

1. Introduction

Retexturing constitutes an essential step towards creating models providing realistic visual representations of real-world objects, i.e. image synthesis [1–4]. In fact, it is intended to incorporate colour information into a model, which may be the result of a 3-Dimensional (3D) reconstruction process [5]. Usually, performing the latter task involves mapping a planar texture image, which contains the desired colour pattern, onto the surface of the object, being referred to as texture mapping [6]. Various techniques have been proposed in the literature for fulfilling the foregoing goal. An intermediate 3D shape [7], direct drawing onto the oct [8,9] and using an exponential fast matching method through making use of geodesic distances [10–12] could be mentioned as examples.

Among the most important applications of retexturing is its usage in 3D virtual garment representation, the realistic appearance of which is vital, and has encouraged many researchers to get engaged in attempts to improve it during the last decade [13–15]. The role it plays in movie and game industries [16,17] is also of paramount importance. One of the most frequently used texture fitting methods was proposed in [18], allowing the users to sketch garment contours directly onto a 2-Dimensional (2D) view of a mannequin. The initial algorithm has later been further enhanced by others [19,20]. An alternative approach to this problem is using a single image. In [21], an estimation of a 3D pose and shape of the mannequin is followed by constructing an oriented facet for each bone, according to their angles, and projecting the 2D garment outlines onto the corresponding facets.

In [22], on the other hand, the focus is on a texture mapping algorithm on the basis of harmonic maps. They project the 3D surface onto a plane, and parametrise it, by means of an *angle-based-flattening* method. The constraints between the feature-points of the model and the texture image are then specified by the user interactively. Afterwards, the texture coordinates are determined using harmonic maps. Additionally, for achieving reliable real-time performance, the whole map is locally refined. The resulting algorithm has been reported to be

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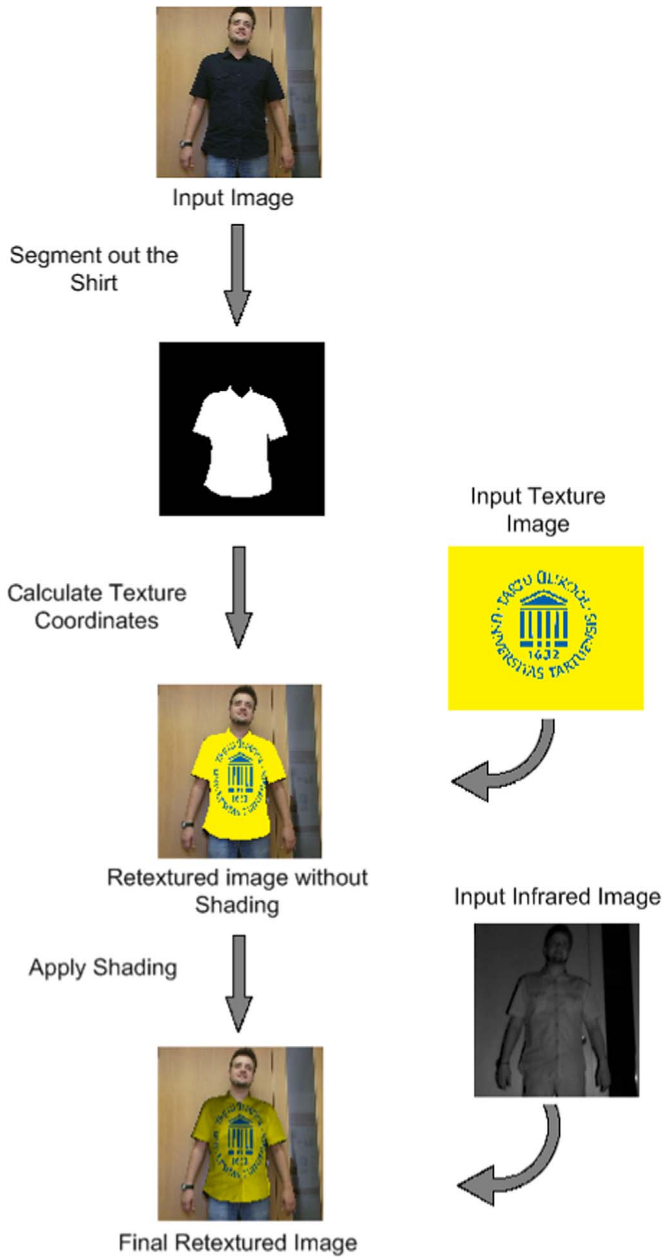

Fig. 1. A Flowchart illustrating the necessary steps of the IRT.

accurate, due to the energy-minimisation embedded into the harmonic maps, which prevents possible distortions.

Retexturing usually involves several challenges. First, texture mapping is difficult in the presence of non-rigid and easily transformable surfaces, such as clothes. One of the main issues to be tackled when dealing with such surfaces is self-occlusion, where a part of the surface blocks the visibility of another one [23]. An additional challenge is to shade the reference texture [24]. Various computer graphics rendering methods could be employed to visualise the surface [25]. However, the lighting intensity and the original colour of the surface are usually not known from the outset, which means that the shading parameters, which are dependent on a map transforming the surface colour to the one reported on the RGB channels, are not available, unless a considerable amount of manual contribution is provided by the user, in non-automatic settings. The foregoing issue is the main reason causing the existing texture mapping methods to degenerate under the changes in the illumination conditions, along with other factors, such as the complexity of the scene.

This paper is aimed at proposing, and verifying the efficiency of, a new approach, referred to as the IR-based Retexturing Method (IRT), which overcomes the above problem, and offers reliable, automatic performance. The underlying notion and the main novelty of the IRT lies in the shading process, which is completely colour- and texture-invariant. In fact, the shading parameters, in the context of the IRT, are extracted from a linear transformation mapping the Infrared (IR) image to the RGB one. More clearly, the pure colour values are derived from the IR image, and, for guaranteeing that the changes of the illumination and other experimental factors are incorporated into the calculations properly, the factors supposed to have been applied to them to produce the RGB representation are extracted, and applied to the reference texture.

The state-of-the-art methods often perform satisfactorily only in cases where the retextured region is sufficiently bright, and its luminance values can be readily utilised. The IRT, however, is able to handle the general case. Furthermore, it operates properly for garments that already have textures on them, which, to the authors' knowledge, is not possible by any of the existing approaches. It is worth noticing that despite the fact that the IRT, based on the experimental results reported in the upcoming sections, is capable of overcoming occlusions and self-occlusions in some cases, these issues are not taken into account in this study, i.e. it is assumed that the garment image does not suffer from such deficiencies.

The IRT has been developed with a focus on virtual fitting room applications [26]. It replaces the texture of a shirt obtained using the Microsoft Kinect II camera with a new custom texture from an image file. As the first step, the image is segmented in order to extract the region standing for the cloth, using two main approaches: Breadth-First Search (BFS) [27] and GrabCut [28]. The latter is intended to minimise the amount of manual contribution required from the user, which will be discussed in more detail throughout the upcoming sections. Then texture mapping is conducted, based on the normalized coordinates of the reference texture image and that of the surface to be retextured. Finally, the aforementioned novel shading approach is incorporated in order to integrate the changes in the illumination and other experimental settings that might have affected the appearance of the surface in the scene. For the sake of evaluating the efficiency of the proposed method, it is examined based on Mean Opinion Score (MOS) analysis, which has resulted in superior scores.

The rest of the paper is organised as follows. Section 2 details the IRT. Section 3 provides a literature review outlining the differences between the IRT and its existing state-of-the-art counterparts. Section 4 presents the results of implementing the IRT under various experimentation scenarios. Finally, Section 5 concludes the paper.

2. Description of the proposed method: IRT

The IRT uses static images from the Microsoft Kinect II camera, along with the depth information and real-world coordinates it provides. Although it is devised such that the most general applications could be handled, the tests are carried out on images that contain a person wearing a shirt. The main application of the IRT is in virtual fitting rooms, where the subject can have the texture of the 3D model of the garment they are wearing changed as they wish.

The IRT replaces the texture of the shirt with a desired reference texture, through performing the following three tasks: segmentation, retexturing and shading. In other words, the part of the image corresponding to the garment worn by the subject is first segmented out, and then retextured by calculating the texture-domain coordinates for each pixel in the area of interest, followed by applying shading to the colour information. The overall step-by-step procedure is shown in Fig. 1, and for more clarity, through the pseudo-code provided in Algorithm 1.