Virtual Face Sculpting

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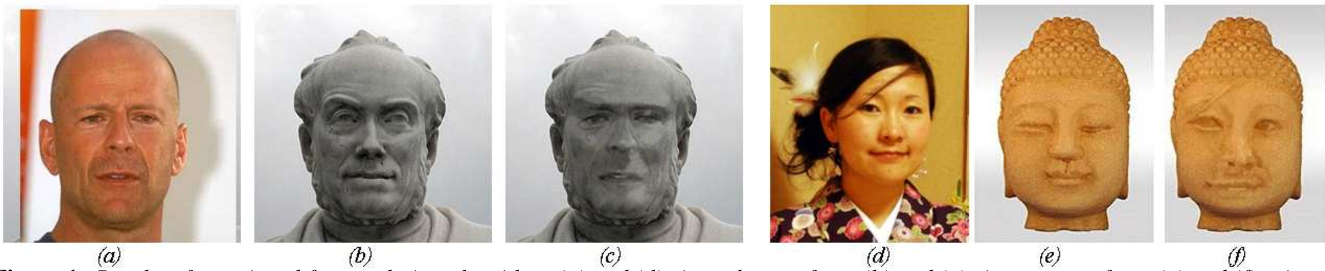

Figure 1: *Results of our virtual face sculpting algorithm. (a) and (d): input human face. (b) and (e): input statue face. (c) and (f): virtual statue face obtained by the proposed algorithm.*

1 Introduction

This paper introduces the new concept of *virtual face sculpting*. Given the images of a human face and a statue face (cf Fig 1-a and b), the goal of this application is to sculpt a virtual statue (cf Fig 1-c) as if the human face was sculpted on the statue. This problem is complicated and must face some important difficulties. For example, the virtual sculpture must verify the color and texture consistency of the original statue. Moreover, the structure of the human face must also not be modified, otherwise the person will not be recognizable.

To the best of our knowledge, this paper is the first attempt for this face sculpture. Nevertheless some existing works could be applied for this task, while it is usually not their primary goal. However these methods either require 3D information of the faces or cannot handle color and texture consistency (e.g. [Perez et al. 2003] or warping).

In this paper, we explain our approach to solve the challenging difficulties of this application and present the results.

2 Our approach

The key difficulty of this application is the fact that two aspects compete with each other. First, the output statue must have coherent color and texture with the original statue, which we refer as the Color and Texture Consistency Problem (CTCP). But, secondly, the output statue must also look like the original human face.

Our approach consists in extracting some patches (i.e. rectangular parts) from the input statue face and combining them in an appropriate configuration. This combination of patches is performed with respect to two constraints: their configuration must (1) respect the structure of the given human face and (2) minimize the "patching effect". We mathematically defined the problem as an energy minimization composed of 2 competitive terms: a similarity term (structure constraint) and a coherence term (overlapping constraint). The similarity term compares two corresponding patches (one from the input statue and one from the human face) by computing the sum of squared differences (SSD) in the gradient domain. This term permits to build the correspondence of patches between the statue and human faces: for example, finding the left eye corner in the statue and human images. Globally, it is used to reconstruct the human face structure from the statue face patches. The coherence term compares two overlapping patches in the output statue by the SSD in RGB colorspace. It is used to find patches that overlap correctly in order to get a smooth image and avoid the "patching effect".

We consider this energy minimization as a graph labeling problem, inspired from [Sun et al. 2005]. This labeling problem is a difficult task due to the high number of labels and the graph connectivity. We applied Belief Propagation (BP) [Pearl 1988] to find the labels (i.e. the patch combination) and also a warping step to drastically decrease the number of candidate patches (i.e. the search space) and impose some apriori geometric information about the faces. This warping needs some point correspondences that can be obtained by automatic facial feature extraction or manually selected.

The proposed method can run automatically and takes about 1 to 20 minutes depending on the image size and the number of iterations, in non-optimized Matlab code. Results obtained by the proposed method are shown in Figures 1 and 2. We have been able to reconstruct some features that cannot be created by existing methods, such as the cheek wrinkle in Fig 1-c and the hair streak in Fig 1-f. Acknowledgments to the Flickr user *Kuwait-Ra'ed Qutena* for Fig 1-a. More results are available on the authors website.

Figure 2: *Extra results obtained by our virtual face sculpting method. Same legend than Figure 1.*

References

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