DETECTING GLASS FIBERS USING COMPUTER VISION

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Abstract

We present an application of computer vision in the field of chemical engineering, the processing of images of glass fibers. Fibers are used as reinforcement for several polymer products to enhance their mechanical and thermal performance. In order to evaluate the properties of the polymer products however, a quantitative measure of fiber length and orientation is required.

The algorithm presented here locates the fibers present in a given image and thus enables their quantification in length and orientation. This algorithm operates in two steps. In the first step, feature points in the image are extracted in order to enable the generation of hypotheses as to the possible presence of fibers. In the second, the generated hypotheses are verified and the hypotheses that yield the highest confidence are retained.

1. Introduction

We present an application of computer vision in the field of chemical engineering, the processing of images of glass fibers. Fibers are used as reinforcement for several polymer products to enhance their mechanical properties and thermal performance. However, the process induced orientation distribution of fibers is anisotropic, and this results in direction dependent mechanical properties. Thus, a quantitative measure of fiber length and orientation is required for predicting the mechanical properties of the product.

In a typical image of glass fibers, the fibers have a high intensity, as opposed to a noisy background which has, on average, a low intensity. In addition, the fibers appear as straight line segments of differing lengths. Thus, looking for fibers, we actually focus our attention on detecting high intensity straight line segments on a low intensity and noisy background. A number of techniques have been developed in order to solve this problem. Relaxation labelling is one of them[1]: using this technique, an initial set of orientations is assigned to the image points, and these orientations are iteratively altered until the orientation at each point becomes the one dictated by its neighborhood. The main drawback of relaxation labelling and similar techniques lies in their excessively large computational complexity, which renders them impractical for most applications. Another technique that is in use for detecting line segments is the Hough transform[2]. The Hough transform is a mapping from image space to parameter space (usually taken as distance and orientation) in which colinear points in the image appear as clusters of points in the parameter space. However, the Hough transform does not distinguish between connected and non-connected points. This results not only in interference between points residing on different segments, but also in ambiguous interpretations of the clusters in parameter space.

We take a different approach for solving the fiber detection problem. For this, we adopt the well known hypothesis prediction/verification paradigm [3].This algorithm consists of two major parts: a predictor, which predicts possible fiber locations, and a verifier, which verifies the predictions and discards those which do not satisfy all of the constraints. Bearing in mind that template matching is itself a form of hypothesis prediction/verification (although of an exhaustive nature), it becomes clear that the main requirement that is imposed on the predictor is that it should significantly limit the scope of its predictions. In other words, the image-based features that are used by the predictor in formulating hypotheses should be closely correlated with the hypotheses themselves. In what follows, the features that are used in formulating hypotheses are described, and the cost function which allows the verifier to prune hypotheses is presented.

The complete algorithm is implemented in the C programming language on a VAX 11-750 running the UNIX operating system.

2. Predicting Fiber Locations

Consider a slide of glass fibers. The slide is illuminated by direct lighting and the reflected light pattern is viewed with a camera mounted on a microscope. This yields an image in which the regions occupied by the fibers have a large gray value, as opposed to the background gray value, which occupies, on average, the low