

# Robust Texture Recognition Using Credal Classifiers

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Texture classification is used in a large number of fields, ranging from industrial applications to remote sensing and biomedical engineering. The problem is traditionally solved by first computing texture descriptors (i.e. feature vectors) from image data and then performing supervised or unsupervised classification.

In this paper we adopt the Local Binary Patterns descriptor [3], and focus on the classification problem, showing that the reliability of classification can be improved by suspending the judgment, namely returning a set of classes rather than a single class, on the instances whose classification is most doubtful. We call *indeterminate* the classifications containing more than one class.

Recently, there has been in machine learning increasing attention towards classifiers able to return more classes on doubtful instances: we focus on the Naive Credal Classifier (NCC) [1], which is an extension towards robustness of the well-known naive Bayes and conformal predictions. It shares part of the assumptions of naive Bayes but, being based on imprecise probability, it returns more classes on the doubtful instances.

The theory of imprecise probability can be seen as a generalizing the traditional Bayesian theory towards robustness [4]; it provides theoretical reasons and practical algorithms to work with a *set* of probability distributions rather than with a single probability distribution. Therefore, classifiers based on imprecise probability (*credal classifiers*) computes, when classifying an instance, a *set* of probability distributions; if the most probable class cannot be consistently identified across all distributions, the credal classifier returns more classes. In general, imprecise probability leads to weaker but more robust conclusions than traditional Bayesian probability.

A conservative approach to classification, which suspends the judgment on the doubtful instances, can generally constitute an advantage for machine vision applications. For instance, assuming that surface defects are categorized for taking appropriate countermeasures, an indeterminate classification containing two classes may trigger a machining able to fix either of the two possible problems, or call for manual evaluation if no such treatment exists.

By comparing naive Bayes and NCC, we show that indeterminate classifications can improve the reliability of classification of textures. In particular, NBC is almost randomly guessing among the classes returned by NCC, when NCC returns an indeterminate classification; we see as more sensible, on the critical instances, returning a reliable set of categories rather than a single but unreliable category.

The ability to return indeterminate classifications is particularly useful when the classification problem is challenging: in practical applications this is often the case, possibly because of the actual appearance of the different texture classes, or due to several factors such as limited size of the training set, small, noisy or defocused images. We thoroughly compare NBC and NCC in texture classification, applying to the standard OUTFEX [2] dataset various disturbances, namely a) reduction of the training set size; b) crop; c) noise; d) blur.

Experimental results show how the imprecise classifier successfully recognizes difficult instances to be classified, thus returning a set of possible classes, ultimately providing a more robust behavior than the traditional NBC. We believe that many applications using texture classification might benefit from such behavior.

As the present approach did not require any special adaptation of the texture descriptor, it can be effortlessly adapted to the vision tasks including a classification step, such as face recognition, gesture recognition, key-point following using random ferns, and many others.

Future experiments might be conducted with more advanced credal

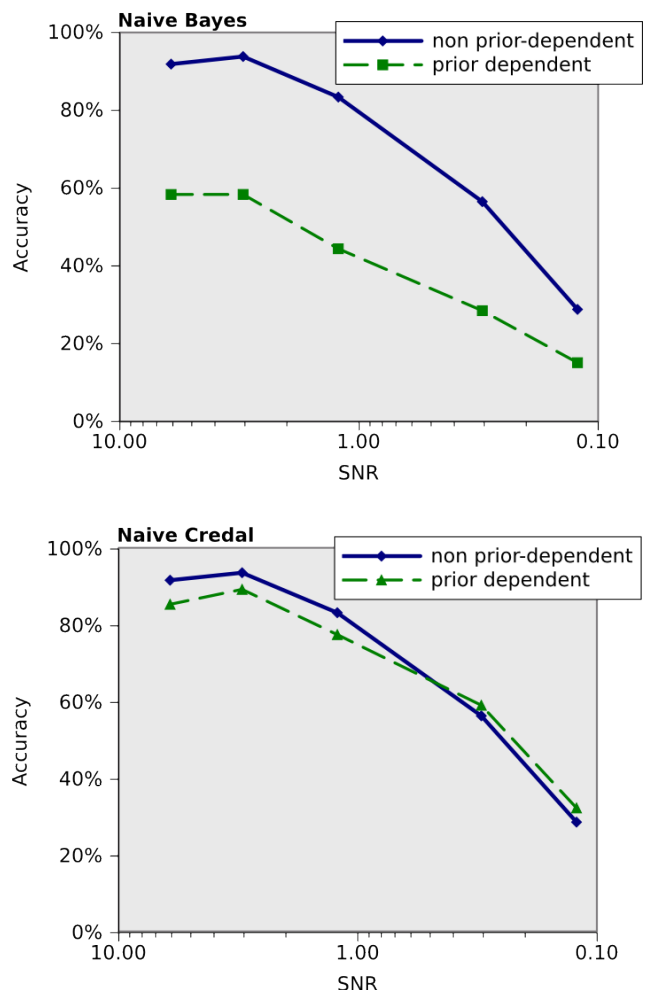


Figure 1: Experimental Results on the OUTFEX dataset. First and second rows show the accuracy of NBC and NCC, respectively, on instances which are prior dependent (light dashed) and non prior-dependent (dark), as a function of increasing noise – expressed as decreasing SNR in log scale. Several other common image degradations are considered in the full paper.

classifiers, no longer based on the naive assumption.

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