

A New Multi-Layered Fuzzy Image Filter for Removing Impulse Noise

Russel J STONIER

Faculty of Informatics and Communication, Central Queensland University,
Rockhampton, QLD 4702, Australia

and

Mohamed M ANVER

Faculty of Informatics and Communication, Central Queensland University,
Rockhampton, QLD 4702, Australia

ABSTRACT

In this paper we develop a fuzzy image filter which consists of a multi-layered fuzzy structure based on the weighted fuzzy blend filter for the removal of noise from images heavily corrupted by impulse noise, while preserving the intricate details of the image. The introduction of multi-layered fuzzy systems substantially decreases the number of rules to be learnt. We then show how Evolutionary Algorithms (EAs) can be used to effectively learn the fuzzy rules in each knowledge base. Results are presented for impulse noise corruption of the well-known 'Lena' image.

Keywords: Fuzzy filter, image enhancement, multi-layered fuzzy system, evolutionary learning, evolutionary algorithm.

1. INTRODUCTION

Conventional image enhancement techniques such as mean and median filtering have been employed in various applications in the past and are still being used. However techniques using Fuzzy Logic (FL) which mimics human reasoning and tolerates ambiguities well are increasingly being looked into as alternatives to these conventional techniques.

When using FL to any practical application, the question arises as to how the fuzzy rule base should be decided. Usually, human intuition is used to decide these rule bases with the intention of seeing a human-like behaviour from the system. However EAs which belong to the category of artificial intelligence techniques is proving to be very powerful when determin-

ing the fuzzy rules in the knowledge base rather than employing human experience and knowledge. This is specifically true in automated processes where the human intervention is a minimum.

In this paper, both FL and EAs are employed to show how they could be used in a practical digital image processing system to remove heavy impulse noise from corrupted images. It is shown how a Multi-Layered Fuzzy Logic (MLFL) structure can be developed as a fuzzy image filter to reduce the high computational power required otherwise.

Section 2 of the paper gives an introduction to MLFL systems. In Section 3 we present a simple analysis of the Weighted Fuzzy Blend Filter presented in [1]. It will be used to construct a two layered fuzzy image enhancement algorithm in Section 4, whose fuzzy rules in each layer will be learnt from corrupted data by an evolutionary algorithm. Application will be made to well-known 'Lena' image and comparisons are made where applicable.

2. MULTI-LAYERED FUZZY LOGIC SYSTEMS

A key consideration when designing FL systems is the size of the rule base, which increases exponentially with the number of inputs - the so called 'curse of dimensionality'. For example consider the 8 input - single output single-layer FL system shown in Figure 1 and the MLFL structure shown in Figure 2. In the MLFL structure the output of the first layer is combined with the output of the second layer to obtain the final output.