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A Review of Digital Image Classification Based on Fuzzy Logic

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ABSTRACT
Fuzzy logic has long been an important issue for in the field of computer science, computer vision, image processing, machine learning and control theory and mathematics. In this review paper, we also see that the basics of fuzzy logic as well as fuzzy logic system (Fuzzy Inference System) use as decision making technique under a linguistic view of fuzzy sets. In this study, we focused to review the fuzzy logic to classification of digital image. The aim of this study was to review the fuzzy logic algorithm for classification of image.

Keywords :fuzzy logic, image classification, image, computer vision.

INTRODUCTION

In computer science, artificial Intelligence, computer vision, machine learning and image processing field has an extremely important place with effective approaches, methods, techniques and wide working domain. The fuzzy logic is one of these techniques which is widely used in today's intelligent problem solving system and applications. The fuzzy logic denotes fuzzy sets which are sets with blurred boundaries, it was introduced by [1]–[3].

Fuzzy logic has been successfully applied in the field of digital image due to its ability to address imprecise, incomplete and vague data. This methodology has also been used in the field of computer vision, although to a lesser extent, with particular relevance to areas such as improve, filtering scoring [4], [5]. However, with regard to the specific field of digital image processing, the footprint of fuzzy logic has been almost non-existent. This absence could be seen as a contradiction, given the properties of fuzzy logic, which seem to fit particularly well in complex and uncertain environments.

Since the image classification is an issue that utilizes image processing, pattern recognition and classification methods. Automatic image classification is a progressive area in image classification, and it is expected to be more developed in the future have been the main priorities within the area of field image processing or computer vision [6].

This priority suggests the importance to both academia and practitioners of exploring this topic through different approaches. Introducing fuzzy logic to the analysis of image processing could represent an important step towards addressing and resolving image more efficiently [7]–[10]. The initial hypothesis of this work is, therefore, that fuzzy logic is a solid tool that can be applied in image classification, image processing and computer vision analyses due to its ability to manage imprecise, incomplete and vague data.

Several works explore the links between fuzzy logic and mathematics. Some studies are focused on this relationship from a historical perspective [11], [12], other studies elaborate on the formal mathematic framework of the Fuzzy Sets Theory [13], while other studies take a step into the links between mathematics and fuzzy logic in practical applications [14].

In addition to the academic works devoted to exploring the generic links between mathematics and fuzzy logic, there are some works focused on analyzing the fuzzy mathematics of image processing. These works seek to show the relevance of fuzzy logic as a useful method to deal with image processing research. In particular, one of the first studies suggesting a potential successful application of fuzzy logic techniques to image proposes using fuzzy alternatives to classic financial data [15], [16]. Other works focused on developing fuzzy

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mathematics in image classification followed, including a generalization of the framework for fuzzy mathematics in image [17]. From that point, as our analysis shows, the number of articles taking advantage of the foundations of fuzzy mathematics in image processing and computer vision increased exponentially.

In line with the above, the goal of this work is to critically examine fuzzy logic as an effective, useful method to be applied to image classification research [17]. For these reasons, we conducted a bibliometric and literature review of a large group of articles indexed in Web of Science and Scopus, in which fuzzy logic has been applied to the image processing field. Additionally, we discuss the potential applications of fuzzy logic in four specific areas, including the prevention of image processing.

METHODS

2.1. Fuzzy Logic

The Fuzzy Sets Theory was initially introduced in 1965 by L. A. Zadeh and can be described as a logic for dealing with uncertainly and imprecision [2]–[4]. The term "fuzzy" is appropriate to describe a mathematical environment where there are no well-defined boundaries between the variables under study. The goal of fuzzy logic is to express the vagueness and imprecision of human thinking with the appropriate mathematical tools. The human way of thinking and reasoning is not binary, where everything is either yes (true) or no (false), and thus Boolean logic is not always the most efficient way to deal with real problems that human beings have to face. Concepts like "danger–safe" or "hot–cold" cannot be sharply defined, and even human beings will use fuzzy language expressions like "very", "a little" or "a lot" to define temperature or dangerous situations.

The fuzzy logic theory is based on the concept of "fuzzy sets", which is a overview of the classical set theory [5], [9]. A crispy set can be defined by a mathematical function that only accepts binary values, meaning that it can only represent elements that fully belong to the set (represented by the value 1) and elements that do not belong to that set (represented by 0). A fuzzy set is defined by a membership function that allows every element to be represented by a different "grade of membership" specifying to which extent the element belong to the set. It is important to observe that the grades of membership are subjective and rely on the context. To illustrate this, consider a cow, which could be labelled as a "big animal" if the universe of disclosure is "farm animals", but probably will be considered a "medium-size animal" if elephants and hippopotamuses are added to the universe of disclosure.

A fuzzy set is described from the universe of discourse, which establishes the reference set and it cannot be fuzzy. Being U = {x1, x2, ..., xn} the universe of disclosure, a fuzzy set F (F U) is always defined as a set of ordered pairs, the second part of the pair being the degree of membership {(xi, F(xi))} and A will always take a value between 0 (non-belonging to the set) and 1 (fully belonging to the set). Various fuzzy sets tend to be defined on the same universe of disclosure forming a partition of the universe. At this point, a linguistic expression will need to be used to label the different fuzzy sets. This is known as the linguistic variable and can be defined as a variable whose values are words instead of numbers. L.A. Zadeh defines a linguistic variable by a quintuple (X,T,U,G,M) where X is the name of the variable, T are the linguistic values of the variable, U is the universe of disclosure, G is the rule to give a name to the terms in T, and M a semantic rule which associates with each linguistic value X its meaning [12], [14].

The mathematic foundations of fuzzy logic include basic concepts previously described, such as fuzzy sets, membership functions and the basic fuzzy operations (intersection, union, and complement). There is a large number of academic papers using fuzzy logic in theoretical fields of traditional mathematics, such as topology, differential equations, probability theory, mathematics, and statistics, or measure and integral theory, which shows the strong link between mathematics and fuzzy logic [12], [13].

2.2. System Review Methodology

Several authors have conducted literature reviews on fuzzy logic applied to dierent knowledge fields, such as decision making, social policy and medical sciences [18], showing a wide range of applications in which fuzzy logic can be used. However, literature reviews of the use of fuzzy logic in image classification published so far are not complete nor comprehensive enough, with some examples focusing on the application of neuro-fuzzy systems in business [14] or the uses of fuzzy logic in insurance. It is noted that some interesting books on the subject exist, although they focus on particular applications rather than providing a general overview of fuzzy logic applied to image [14], [17], [18].

There are several ways to approach a literature review, with theoretical background literature reviews being the most common, and hence the approach followed in this study. In particular, two essential forms of analysing the literature regarding a given topic are found: within-study literature analyses and between-study literature studies [15]. The former refers to analysing a specific work while the latter involves contrasting the content of several sources. Some of the benefits of a theoretical background literature review include highlighting what has been explored in a given area and what is still pending to be explored, identifying links between key concepts and listing the main analysis and methodologies that have been successfully used [12].

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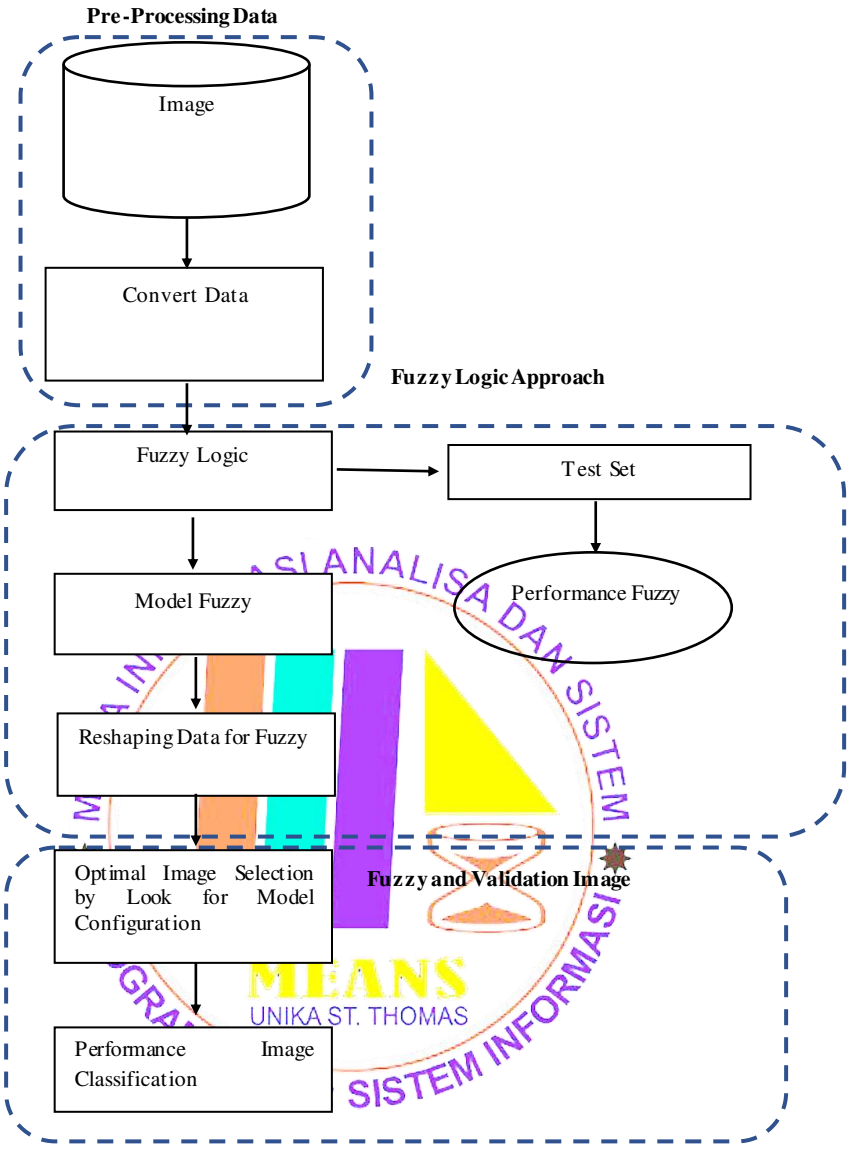

Fig. 1. A general methods system

The general methods in this study based on fuzzy logic can show in Fig. 4. The fuzzy logic can performance using another field artificial intelligence, machine learning, deep learning, computer vision to the classification of the image as shown in the flow diagram.

CONCLUSSION

In this study, we have to merge the fuzzy logic approach and digital image processing. The Fuzzy Logic provides a different way to approach a control or classification problem. This method focuses on what the system should do rather than trying to model how it works. One can concentrate on solving the problem rather than trying to model the system mathematically if that is even possible. On the other hand, the fuzzy approach requires sufficient expert knowledge for the formulation of the rule base, the combination of the sets and the defuzzification. In General, the employment of fuzzy logic might be helpful, for very complex processes, when there is no simple mathematical model (e.g. Inversion problems), for highly nonlinear processes or if the processing of (linguistically formulated) expert knowledge is to be performed. According to literature, the employment of fuzzy logic is not recommendable, if the conventional approach yields a satisfying result, an easily solvable and adequate mathematical model already exists, or the problem is not solvable.

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