Rough Sets-Based Image Processing for Deinterlacing

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Summary. This chapter includes the rough sets theory for video deinterlacing that has been both researched and applied. The domain knowledge of several experts influences the decision making aspects of this theory. However, included here are a few studies that discuss the effectiveness of the rough sets concept in the field of engineering. Moreover, the studies involving a deinterlacing system that are based on rough sets have not been proposed yet. This chapter introduces a deinterlacing method that will reliably confirm that the method being tested is the most suitable for the sequence. This approach employs a reduced database system size, which contains the essential information for the process. Decision making and interpolation results are presented. The results of computer simulations show that the proposed method outperforms a number of methods that are presented in literature.

20.1 Introduction

The current analog television standards, such as NTSC, PAL, and SECAM, are based on interlaced scanning formats. Because the video industry is transitioning from analog to digital, video processing equipment increasingly needs to transition from analog to digital as well. Thus, the demand for progressive material will increase, which causes a directly proportional increase in the demand for video processing products with high quality deinterlacing. Deinterlacing methods can be roughly classified into three categories: spatial domain methods [1],[2], which use only one field; temporal domain methods [3], which use multiple fields; and spatio-temporal domain methods [4]. The most common method in the spatial domain is Bob [2], which is used on small LCD panels. However, the vertical resolution is halved, and this causes the image to have jagged edges. Weave is the most common method in the temporal domain [3]. However, this method gives motion artifacts. There exist many edge direction based interpolation methods. The edge line average (ELA) algorithm was proposed to interpolate pixels along the edges in the image [1]. Oh et al. propose a spatio-temporal line average (STELA) algorithm. ELA utilizes only the spatial domain information. However, the amount of data
limits the interpolation by causing missed pixels at complex and motion regions. Thus, STELA was proposed in order to expand the window to include the temporal domain. Generally, various features offer several attributes for the nature of a sequence. However, sometimes the attributes become too much to make essential rules. Although some rules are decided, even human experts are unable to believe the rules. Thus, the conventional deinterlacing method cannot be applied to build an expert system. In order to create an expert system, rough sets theory is applied to classify the deinterlacing method. In this theory, prior knowledge of the rules is not required, but rather the rules are automatically discovered from a database. Rough sets theory provides a formal and robust method of manipulating the roughness in information systems [5]. It has been applied to several areas including knowledge discovery [6],[7],[8],[9], feature selection [10], clustering [11], image recognition and segmentation [12],[13],[14], quality evaluation [15], and medical image segmentation [16],[17],[18]. It has proved its advantage in real world applications, such as semiconductor manufacturing [19], landmine classification [20], fishery applications [21], and power system controllers [22]. Rough sets theory has been used in imaging, but its application in video deinterlacing has yet to be investigated. This chapter presents a decision making algorithm that is based on rough sets theory for video deinterlacing. The operation of a decision in the deinterlacing method is intrinsically complex due to the high degree of uncertainty and the large number of variables involved. The analysis performed by the operator attempts to classify the operational state of the system in one of four states: plain-stationary region, complex-stationary region, plain-motion region, or complex-motion region. The proposed rough sets deinterlacing (RSD) algorithm employs four deinterlacing methods: Bob [2], Weave [3], ELA [1], and STELA [4]. In Section 20.2, the basic concepts of the rough sets theory are discussed. In Section 20.3, the proposed rough sets deinterlacing algorithm is described. In Section 20.4, the experimental results and performance analysis are provided to show the feasibility of the proposed approach. These results are compared to well-known, pre-existing deinterlacing methods. Finally, conclusions are presented in Section 20.5.

20.2 Basic Concepts of Rough Sets Theory

Rough sets, introduced by Pawlak et al., is a powerful tool for data analysis and characterizing imprecise and ambiguous data. It has successfully been used in many application domains, such as machine learning and expert systems [5].

20.2.1 Preliminary

Let $U \neq \emptyset$ be a universe of discourse and $X$ be a subset of $U$. An equivalence relation, $R$, classifies $U$ into a set of subsets $U/R = \{X_1, X_2, \ldots, X_n\}$ in which the following conditions are satisfied: