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AN IMAGE VERIFICATION FRAMEWORK DEVELOPMENT

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An efficient representation and implementation of image are necessary, as a digital image is an approximation of some real situation, and carries some uncertainty. In order to deal with this uncertainty we need appropriate image model, which also enable image processing without losing the information regarding the uncertainty. Interval arithmetic techniques appear as a good option for handling the uncertainty. In this work we focused the extension of the classical notion of digital image, in the which each pixel has as degree of intensity an exact value to the interval digital image one, where each pixel possesses an interval intensity that include lower and upper bound of every pixel of an image as image verification model. The time consuming process of image data processing can be address using parallel computing techniques that provide an efficient and convenient way to address this issue. The paper concludes that considering the interval arithmetic in designing solutions for some applications may impact the performance of algorithms and the image processing tasks may benefit from an image verification model.

Keywords: interval arithmetic, image processing, uncertainty, parallel computing.

1. Introduction

In image processing tasks, there are various sources of ambiguity and uncertainty to be considered when performing the processing [1]. Images captured situations are not always ideal or stable; this is one of examples of uncertainty regarding the measured pixel values, Also which in some cases is related to the spatial position of an image object or technical limitations. So, in practice we always deal with numerical and spatial approximations of pixel values. To overcome this uncertainty we need suitable image models, which also enables to image processing without losing the information regarding the uncertainty. Since information on the level of uncertainty will influence an expert's attitude, so the ability to propagate the uncertainty information during image processing tasks can be very important. In order to deal with the uncertainty – in such a manner that it is incorporated in an image model and can be processed together with an image – an image verification framework introduced based on interval arithmetic.

Interval arithmetic is a powerful tool to deal with the uncertain data, the concepts of interval arithmetic are discussed in [2-3] and some of the related work in interval arithmetic and interval valued fuzzy set presented in [4-9]. In a grayscale image, the pixel value indicates the amount of white or black existing at that specific position in an image [10-12]. In image processing, most algorithms assumes that the pixel values are certain, although in practice the measured values of pixels might be uncertain and just indicate a likely value of an image at a specific location. The uncertainty of the pixel value is an immediate fact if considered that any tool will round captured values of pixel down or up to the finite set of allowed values. The uncertainty of the pixel value is an immediate fact if considered that any tool will round captured values of pixel down or up to the finite set of allowed values. This might be the issue under identical registration circumstances, and will grow when these circumstances change (e.g., weather conditions); Also, the pixels that belong to an edge of an object might slightly shift position in various takes (e.g., while the camera slightly shifts position), this could result in large differences in the measured value of a specific pixel, and consequently in a large uncertainty of the real value of that pixel, i.e., for that specific spatial position in an image; the process of digitalization, it's naturally a level of uncertainty, as the intensity of gray tones of the pixel in a digital image will never correspond the existent in the nature, as an image refers to a continuous function, denoted by $I(x,y)$, where the value of $I(x,y)$ in the coordinates space gives an image brightness (intensity), the digitalization of value quantification called gray levels and the digitalization of the space coordinates called sampling of an image. So, for these reasons, it's appropriate to compute with grayscale intervals, where the interval represents the set to which the actual grayscale values belongs. Various applications in image processing and bioinformatics may benefit from an image verification model.

The paper describes the efficiency of applying interval arithmetic in image representation to get an image verification model. This model allows obtaining better result in image processing tasks, although it requires a lot of calculations and, as a result, a lot of time to perform the task. To solve this problem, we suggest the use of parallel computing which is one of the possible solutions of the problem concerning complex algorithms, as it allows using the available computing resources to the maximum [13-15]. The use of parallel computing can significantly accelerate the implementation of program, the degree of parallelism and the acceleration is fixed by the number of independent computations performed simultaneously and this discuss in section 3.

2. Image Verification Framework

2.1 Interval Arithmetic Fundamentals

The concept of interval analysis is to compute with intervals of real numbers instead of real numbers and it considers a powerful tool to determine the effects of uncertain data. The closed interval denoted by $[a\,,b]$ is the set of real numbers given by

$$[a\,,b] = \{x \in R : a \leq x \leq b\} \tag{1}$$

The left and right endpoints of an interval [x] will be denoted by $\underline{x}$ and $\overline{x}$, respectively. Thus, two intervals $[x] = [\underline{x}, \overline{x}]$ and $[y] = [\underline{y}, \overline{y}]$ are said to be equal if they are the same sets. Operationally, this happens if their corresponding endpoints are equal:

$$[x] = [y] \; iff \; \underline{x} = \underline{y} \text{ and } \overline{x} = \overline{y} \tag{2}$$

The midpoint of [x] is given by

$$mid([x]) = (\overline{x} + \underline{x}) / 2 \tag{3}$$

We are about to define the basic arithmetic operations between intervals. The key point in these definitions is that computing with intervals is computing with sets. For example, when we add two intervals, the resulting interval is a set containing the sums of all pairs of numbers, one from each of the two initial sets. By definition then, the sum of two intervals [x] and [y] is the set

$$[x] + [y] = [\underline{x} + \underline{y}, \; \overline{x} + \overline{y}] \tag{4}$$

We will return to an operational description of addition momentarily (that is, to the task of obtaining a formula by which addition can be easily carried out). But let us define the remaining three arithmetic operations. The difference of two intervals [x] and [y] is the set

$$[x] - [y] = [\underline{x} - \overline{y}, \overline{x} - \underline{y}] \tag{5}$$

The product of [x] and [y] is given by

$$[x] * [y] := \{x * y | x \in [x] \in y \in [y]\} \tag{6}$$

The division of [x] and [y] is given by

$$[x]/[y] := \{x/y | x \in [x] \in y \in [y]\} \tag{7}$$

Note that the result of an interval operation is also an interval (except for the special case of division by an interval containing zero). Specific equations for interval operations are

$$[x] \cdot [y] = [min\,(\underline{x}\underline{y}, \underline{x}\overline{y}, \overline{x}\underline{y}, \overline{x}\overline{y}), max\,(\underline{x}\underline{y}, \underline{x}\overline{y}, \overline{x}\underline{y}, \overline{x}\overline{y})] \tag{8}$$

2.2 Verification Image Model

To overcome the various types of uncertainty and vagueness when doing image processing tasks, as most of those types are contextual, in the sense that they could be present (or not) in an image, based on the situation of an image was captured at. We use a verification interval-valued representation of an image. From an image I, we generate the verification interval-valued images $IV_{(L)}$, $IV_{(U)}$ and $IV_{(M)}$ as following:

$$IV_{(L)} = [max(0, \quad I_{(x,y)} - 1)] \tag{9}$$

$$IV_{(U)} = [min(255, \quad I_{(x,y)} + 1)] \tag{10}$$

$$IV_{(M)} = \left[\frac{IV_{(L)} + IV_{(U)}}{2}\right] \tag{11}$$

That is, we assign to each image position an interval as $IV_{(L)}$ and $IV_{(U)}$ images encompassing all of the brightness values modified by ± 1 tone and $IV_{(M)}$ is the midpoint image of an interval images $IV_{(L)}$ and $IV_{(U)}$. So, once we have interval representation images, then we can apply different strategies of computing as; we can apply the computing strategies individually for $IV_{(L)}$, $IV_{(U)}$ and $IV_{(M)}$ images or together. Figure 1, includes an example of the “Blood Cell” image, together with the verification interval-valued representation.

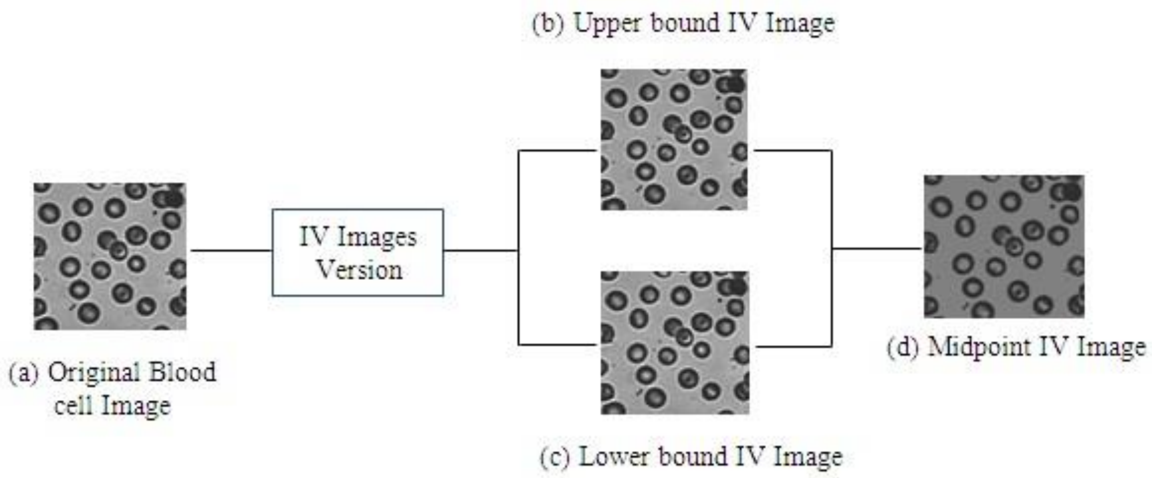

Figure 1. Schematic overview of an interval valued model of "Blood Cell" image where different steps can be observed, Original image (a) is divided into two parts (Upper bound $IV_{(U)}$ image (b) and lower bound $IV_{(L)}$ image (c)) following the midpoint $IV_{(M)}$ image (d)

3. JINR Parallel Computing Infrastructure

JINR actively participates in different international projects which are relied on advanced computing technologies. A unique computer infrastructure has been created at LIT JINR [14], which makes it possible to use a supercomputer, a hybrid cluster, and cloud computing for research.

The cloud computing successfully develops in the field of computer technologies. This direction is the development of such technologies as the use of remote computer resources by Internet. The reason for the development of cloud computing platforms is the increased need for supercomputer resources available to end users for parallel computing.

"HybriLIT" heterogeneous cluster is a computation component of a multifunctional centre for data storage, processing and analysis of the LIT JINR [15]. It is intended for performing computations with the use of parallel programming technologies. Heterogeneous structure of computational nodes allows developing parallel applications for the solution of a wide range of mathematical resource-intensive tasks using the whole capacity of Multicore component and computation accelerators. The main goal of the project is the development and implementation of a software package for analysis of the large set of images with the ability to perform computations on high-performance computing systems. Following the trends of the last decade, as the high-performance system selected the most promising for today - heterogeneous computing systems that include in their structure not only multi-core processors, but also NVIDIA graphics accelerators and processors Intel Xeon Phi. To use all the capabilities of such systems, it is necessary to develop parallel algorithms for already existing single-threaded versions of algorithms implementations.

The transition to advanced digital technology, such as high-performance hybrid computing technologies (parallel computing technologies on a cluster, on a graphic cards, etc.), for solution of a similar class of problems, allows in a short time to obtain physically significant world-class results.

Thus, the research tasks consist in the parallelization of the computational algorithms, choosing of hardware platform and optimization of the programs taking into account its features. The realization of these works suggests the development of the Verification Framework for Image Analysis based on Interval Arithmetic using resources of the Multifunctional Information and Computing Complex LIT JINR.

4. Conclusion

In this paper we introduced and justify an interval-based representation of images, proposed for better managing their inherent ambiguity. An image verification framework presented based on concepts of interval arithmetic, to overcome the uncertainty and enables to propagate this uncertainty through image processing tasks. In image processing applications, experts will be able to judge the uncertainty of the results, and can modify their attitude towards the information accordingly. Also, we discussed the use of parallel computing techniques to overcome the time consuming of image processing using image verification framework model.

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