IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 10, Issue 2, Ver. III (Mar - Apr.2015), PP 28-34
www.iosrjournals.org

ROI Coding of Remote Sensing 2-D images using Shape Adaptive Reversible Integer Lapped Transform

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Abstract: *Image compression is the application of data compression on digital images. Image compression can be lossy or lossless. Raw data from an image sensor obviously contains information about a scene, but it is not intrinsically recognizable to the human eye. This thesis proposes a new shape-adaptive (SA) transform, shape-adaptive reversible integer lapped transform (SA-RLT) method. Region-of interest (ROI) coding algorithms have also been proposed, since observers are always more concerned about some special areas, i.e, ROI than the background (BG) area. Based on SA-RLT and object-based set partitioned embedded block coder (OBSPECK), a new ROI compression scheme can be designed for 2D remote sensing images. A new ROI segmentation algorithm is used here to segment out ROI other than hand segmentation.*

Keywords: *Image Compression;Discrete Wavelet Transform (DWT); Discrete Cosine Transform (DCT); Region of interest (ROI); Shape Adaptive Reversible Lapped Transform (SARLT).*

I. Introduction

Remote sensing images have an important role in many fields such as environmental monitoring, geology detection, urban planning etc. Since these images will take up a great deal of storage space and bandwidth with increase in spatial resolution, compression techniques have been widely researched. Region of interest (ROI) coding algorithms also have much importance since observers are always more concerned about some special areas than background areas. A better lossless compression technique for remote sensing images based on shape adaptive reversible lapped transform (SA-RLT) which is having more advantages than other present SA transform methods is proposed. A comparison between the existing SA transforms such as SA-DWT, SA-DCT and the new SA-RLT method is made and it is analyzed that SA-RLT has preserved the information and is better than the other transforms. The proposed thesis includes a new SA-RLT based ROI coding scheme for 2-D remote sensing images.

The aim of source coding or data compression is to represent discrete signal s(n) with only a small expected number of bits per sample (the so called bit rate), with either no distortion (lossless compression), or as low distortion as possible for a given rate (lossy compression). Since we try to optimize the trade-off between distortion and rate on the average, we regard signals as random which we describe by their statistical properties. The essential step in source coding is quantization.

In PCM strong statistical dependencies exists between signal samples. Normally in PCM sample is quantized individually at a fixed number of bits, e.g. eight bits for grey level images[1].

Most signals representing meaningful information, however, exhibit strong statistical dependencies between signal samples. In images, for instance, the grey levels of neighbouring pixels tend to be similar. To take such dependencies into account, possibly large sets of adjacent samples should be quantized together. Unfortunately, this unconstrained approach leads to practical problems even for relatively small groups of samples.

In transform coding, the signals or images are first decomposed into adjacent blocks or vectors of N input samples each. Each block is then individually trans- formed such that the statistical dependencies between the samples are reduced, or even eliminated. Also, the signal energy which generally is evenly distributed over all signal samples s(n) should be repacked into only a few transform coefficients. The transform coefficients S(k) can then be quantized individually. Each quantizer output consists of an index i(k) of the quantization interval into which the corresponding transform coefficient falls. These indices are then coded, e.g. by a fixed length code or an entropy code[2][3].

The decoder then first reconverts the incoming bit stream into the quantization indices, and then replaces the quantization index i(k) for each transform coefficient S(k) by the centroid V(i(k)) of the indexed quantization interval, which serves as approximation, or better, estimate, bS(k) = V (i(k)) of S(k). The relation between the indices i(k) and the centroid V (i(k)) is stored in a look-up table called a codebook[2]. An inverse transform then calculates the reconstructed signal. Clearly, due to quantization, the compression technique is lossy. Optimizing a transform codec needs to address choosing an optimal transform and optimal scalar quantization of the transform coefficients. Practical transform codec employ linear unitary or orthogonal transforms. Linear transforms explicitly influence linear statistical dependencies, that is, correlations

The principles of image compression are based on information theory. The amount of information that a source produce is Entropy. The amount of information one receives from a source is equivalent to the amount of the uncertainty that has been removed.

A source produces a sequence of variables from a given symbol set. For each symbol, there is a product of the symbol probability and its logarithm. The entropy is a negative summation of the products of all the symbols in a given symbol set. Compression algorithms are methods that reduce the number of symbols used to represent source information, therefore reducing the amount of space needed to store the source information or the amount of time necessary to transmit it for a given channel capacity. The mapping from the source symbols into fewer target symbols is referred to as Compression and Vice-versa Decompression.

Image compression refers to the task of reducing the amount of data required to store or transmit an image. At the system input, the image is encoded into it's compressed from by the image coder. The compressed image may then be subjected to further digital processing, such as error control coding, encryption or multiplexing with other data sources, before being used to modulate the analog signal that is actually transmitted through the channel or stored in a storage medium. At the system output, the image is processed step by the step to undo each of the operations that were performed on it at the system input. At the final step, the image is decoded into its original uncompressed form by the image decoder. If the reconstructed image is identical to the original image the compression is said to be lossless, otherwise, it is lossy[1].

ROI coding of 2-D remote sensing images based on SA-RLT performs better than other existing methods. However, it comes along with some drawbacks. ROI area is segmented by hand in the method. This will create more complexity in studying a particular region from the image as hundreds of images are obtaining at same instance from satellite. Also it will be much difficult to find out the particular region of interest from the satellite image with the help of human eye. So, hand segmenting the ROI area will create more complexity and consume more time.

The method can be used for any type of imaging devices but concentration in the field of satellite images. For several decades remote sensing images have played an important role in many fields such as meteorology, agriculture, geology, education etc. Because of the rising demand for high quality remote sensing images without losing any information while compression. Demand for ROI coding algorithms have increased as observers are always more concerned about some special areas than background areas

II. Methodology

In this section the detailed procedure for compression and segmentation of images are given.

A. Image Compression

In the compression procedure, lossless compressions are introduced. DWT and RLT algorithms are used to implement compression of images.

Compression techniques have been widely researched since images will take up a great deal of storage space and bandwidth particularly with the increase of spatial resolution. Among various compression techniques, lossy-to-lossless compression technique exhibits great flexibility, because it is able to compress images at a high compression ratio at the cost of losing some minor information and it is also able to realize lossless compression without any information distortion. Region-of interest (ROI) coding algorithms have also been proposed, since observers are always more concerned about some special areas (i.e., ROI) than the background (BG) area.

B. RTDLT

RTDLT [4][5] belongs to block transform. Thus the source image will be segmented into adjacent non overlapping blocks before transforming. First, reversible integer prefiltering is done on neighboring blocks to reduce redundancy. Floating point prefilter may be defined as,

$$F = \begin{bmatrix} I & J \\ I & -J \end{bmatrix} \begin{bmatrix} I & 0 \\ 0 & V \end{bmatrix} \begin{bmatrix} I & J \\ J & -I \end{bmatrix}$$

V is defined as,

$$V = \begin{bmatrix} J(C_N 11)TD_S C_N J & O_{N\left(\frac{M}{2}-N\right)} \\ O_{\left(\frac{M}{2}-N\right)} & I_{\left(\frac{M}{2}-N\right)\left(\frac{M}{2}-N\right)} \end{bmatrix}$$

$$C_N(n,k)=\sqrt{2/N}.\varepsilon K.\cos(2nH)\ k/2n$$

where $n, k = 0,1,2, \dots\dots\dots.. N-1$

$\epsilon k = \sqrt{1/2}$ if k=o; otherwise $\varepsilon = 1$

$C_N(n,k)=\sqrt{2/N}.\cos \pi(2n+1)(2K+1)/4N$

where $n, k = 0,1,2, \dots\dots\dots\dots N-1$

Now 2-D reversible integer DCT is performed on each block by cascading 1-D RDCT along vertical and horizontal directions separately.

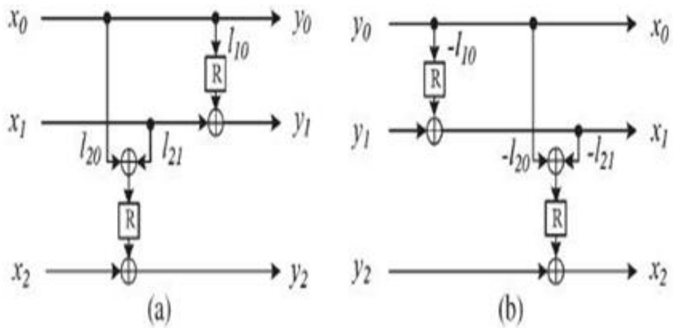
C. Proposed Sa-RLT

Based on RTDLT, we propose SA-RLT with the same concept as used in SA-DCT and SA-DWT. However, SA-RLT has its special advantages .The first one is that SARLT belongs to block transform; as a result, its computational memory requirement is lower than that of global transforms, and its hardware implementation can be parallel processed. The second one is that SA-RLT exploits the correlation between neighboring blocks; therefore, it can improve the efficiency of conventional block-based transforms. Moreover, SA-RLT can realize reversible integer-to-integer transform. How to realize SA-RLT is discussed as follows.

We first compute prefilter and DCT matrices of different sizes. Segmenting image into 8×8 blocks has been proved to be the best trade of between transform performance and computational complexity in conventional DCT based compression schemes such as JPEG. Therefore, in our scheme, basic transform matrices with a size of $2 \times 2 - 8 \times 8$are computed first. Second, we design a multilifting scheme for prefilter and DCT matrices obtained from the first step. To do this, we use the matrix factorization method to factorize basic matrices into TERMs. Suppose that matrix L is a lower TERM factorized from basic transform matrix with a size of 3×3. Then, its multilifting scheme can be obtained [5].

D.Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) [6] is a technique for converting a signal into elementary frequency components. It is widely used in image compression. Here we develop some simple functions to compute the DCT and to compress images. Image Compression is studied using 2-D discrete Cosine Transform. The original image is transformed in 8-by-8 blocks and then inverse transformed in 8-by-8 blocks to create the reconstructed image. The inverse DCT would be performed using the subset of DCT coefficients. The discrete cosine transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain[7].



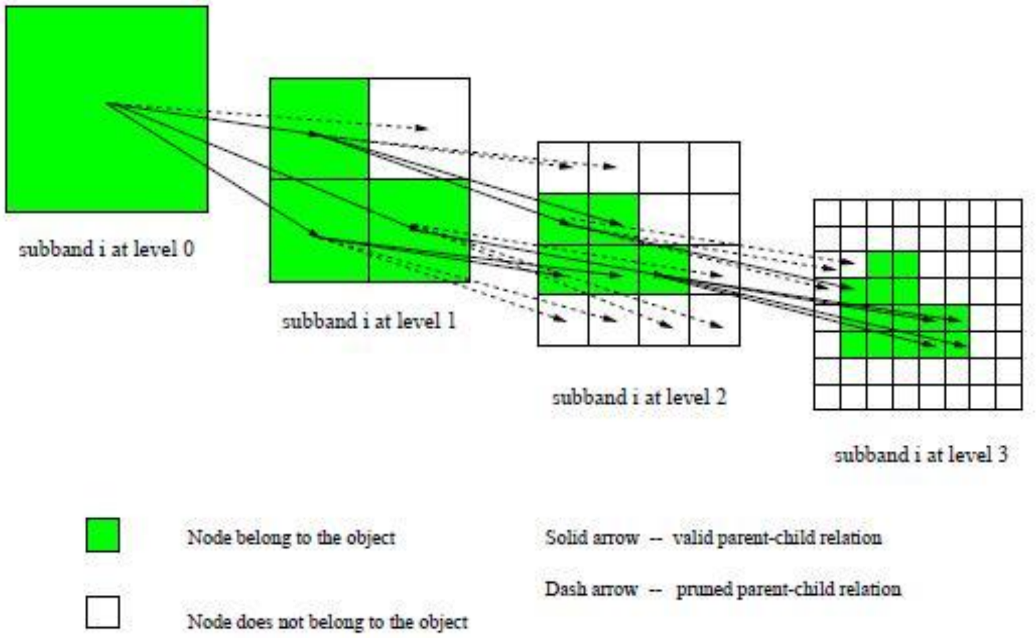
In this way, reversible integer prefilter and DCT for 1-D arbitrary-length vectors have been obtained. A 2-D transform can be obtained by cascading 1-D transform along the vertical and horizontal directions, respectively. It should be noted that the lengths of vertical and horizontal vectors may be different, and each length should be figured out by scanning the vector before transform. Up to now, we have achieved reversible integer prefilter and DCT for arbitrarily shaped image area. In one arbitrarily shaped image area, there exist two types of blocks. The first type of block is incomplete, which is along the area boundary; the second type of block is full, which is inside the image area. We employ different strategies on these two types of blocks. On one hand, we use SA-RDCT for incomplete blocks and use RTDLT for full blocks. Thus, strictly speaking, SA-RLT means the integration of SA-RDCT and RTDLT [5]. In fact, we have taken experiments to perform SA-R-Filter on incomplete blocks along object edges, but the performance improvement is very limited. Therefore, to reduce complexity, we perform SA-RLT employing the aforementioned strategies. There exists no truncation error in the transformation process, since SA-RLT can realize completely reversible integer to- integer transform on both incomplete and full blocks in arbitrarily shaped image area. Therefore, SA-RLT[8] can be applied in both lossy and lossless compressions.

E. SA-RLT Based Roi Coding For RSI

One advantage of the proposed scheme over JPEG2000-ROI coding is that it codes ROI[9] and BG separately; therefore, bit rate can be controlled more flexibly, and ROI can be coded losslessly without BG. First, we apply SA-RLT to ROI and BG, respectively. Coefficients will be distributed in a blocky structure after transforming. Most energy will be concentrated in the left-upper corner of each block. In order to code the transform coefficients of SA-RLT using wavelet-based codec, we reorganize the blocky coefficients into sub band structure like that in wavelet transform. Second, we code these coefficients using object-based set partitioned embedded block (OB-SPECK).OB-SPECK [10][11] is an efficient algorithm for coding arbitrarily shaped object. It can be proved that OB-SPECK performs better than the state of-the-art image compression techniques such as traditional SPIHT, SPECK, and JPEG2000 for region-based digital mammography. Moreover, it possesses characteristics of low complexity and embedded/progressive bit streams. A binary shape mask, which corresponds to the ROI area, is coded by OB-SPECK independently and transmitted with the whole bit stream.

F. Object-Based Speck Algorithm

A straightforward extension of the SPECK[11] algorithm to coding of video objects of arbitrary shape is that we set all the coefficients outside the object in each sub band to zero. Then the original SPECK algorithm can be applied just as if the support of the object were rectangular[12]. No modification of the algorithm would be required.



In the parent-child relation in the OB-SPECK algorithm, the branches, which correspond to the nodes outside the object (represented by the dash arrows), are pruned before the coding process begins.

This method is in efficient, since one bit must be transmitted to tell the decoder that the node or branch outside the object is insignificant under each threshold. In this scheme, the shape information of object area in the wavelet domain is integrated into the coding process[13]. Similar to the object-based wavelet decomposition, the shape image is also decomposed into a pyramid of sub bands, called the shape mask pyramid .In this way, the regions which belong to the object in each sub band are known by both the encoder and the decoder. Each pixel of the shape mask has a 2-bit mask value: 1 bit is used to distinguish if the current wavelet coefficient is within the object; and the other bit is used to tell if its child branch is within the object. When the spatial orientation tree is constructed, which node and/or child branch are inside/outside the video object is known. Before the coding process, we prune the node and branch which are outside the video object. During the sorting pass in the SPECK algorithm, those nodes and branches are not added into any list of LSP, LIP and LIS[14]. Therefore, no information about these nodes and branches are transmitted. When the encoder and decoder scan these nodes and branches, they will be informed by the shape mask pyramid and skip over them[15].

III. Result And Discussion

DCT, DWT, SARLT compression were done on input remote sensing image and a comparison study was done. ROI coding based on SARLT was carried out

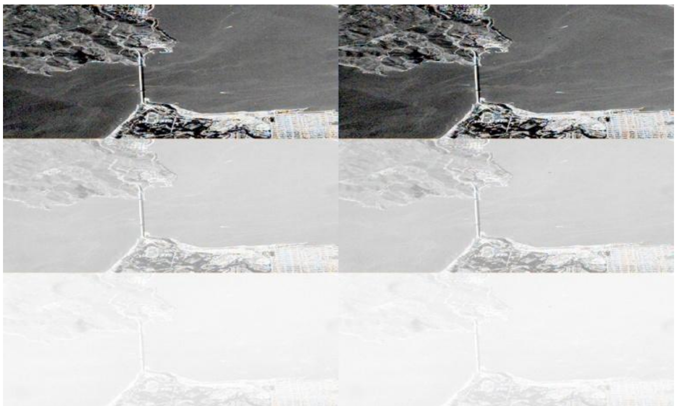


Fig.1**:** Input image

Compression techniques have been widely researched since images will take up a great deal of storage space and bandwidth particularly with the increase of spatial resolution. Among various compression techniques, lossy-to-lossless compression technique exhibits great flexibility, because it is able to compress images at a high compression ratio at the cost of losing some minor information and it is also able to realize lossless compression without any information distortion.

Gray Scale Image

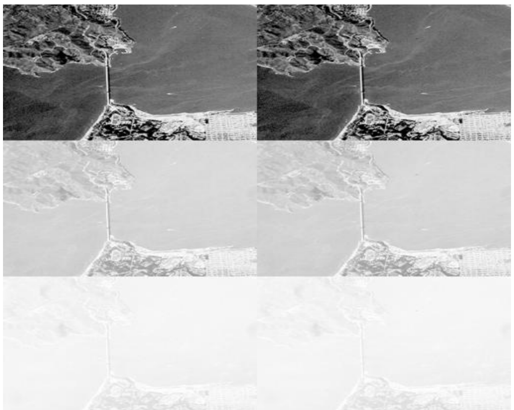


Fig.2**:** Grey Scale Image

Remote sensing images are compressed in order to reduce size. Usually DCT, DWT, LT compressions are done on RSI. Before compression RSI are converted to Grey scale images and to filtered images. Grey scale and filtered images of input RSI are shown in Fig 4.2 and Fig 4.3.

Filtered Image

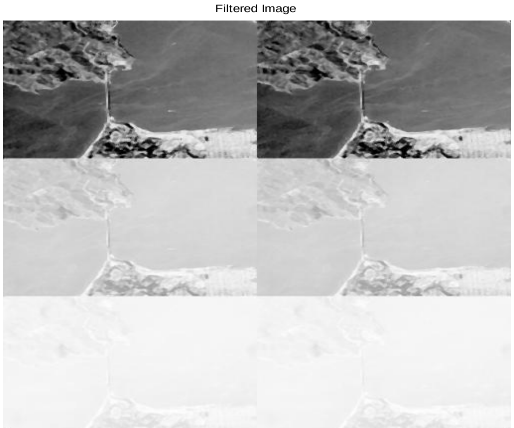


Fig.3**:** Filtered image

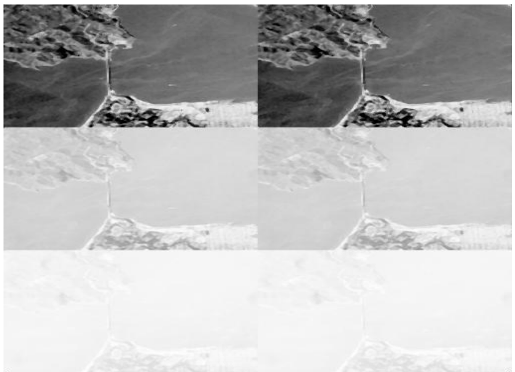


Fig.4**:** DWT compressed image

Shape-adaptive wavelet coding is needed for efficiently coding arbitrarily shaped visual objects, which is essential for object-oriented multimedia applications. The challenge is to achieve high coding efficiency while satisfying the functionality of representing arbitrarily shaped visual texture. One of the features of the SA-DWT's is that the number of coefficients after SA-DWT's is identical to the number of pixels in the original arbitrarily shaped visual object.

Another feature of the SA-DWT is that the spatial correlation, locality properties of wavelet transforms, and self-similarity across sub bands are well preserved in the SA-DWT. Also, for a rectangular region, the SA-DWT becomes identical to the conventional wavelet transforms.

There are two components in the SA-DWT. One is a way to handle wavelet transforms for arbitrary length image segments. The other is a sub sampling method for arbitrary length image segments at arbitrary locations. The SA-DWT allows odd- or small-length image segments to be decomposed into the transform domain in a similar manner to the even- and long-length segments, while maintaining the number of coefficients in the transform domain identical to the number of pixels in the image domain.

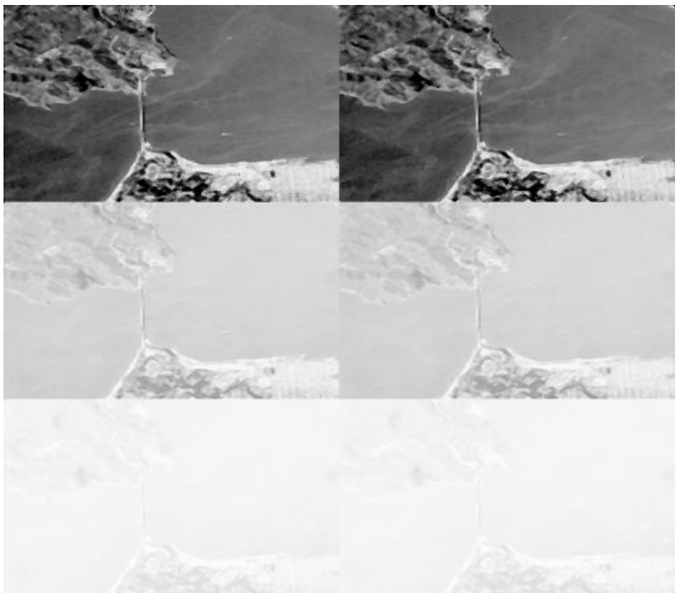


Fig.5**:** SARLT compressed RSI

We first compute pre filter and DCT matrices of different sizes. Segmenting image into 8×8 blocks has been proved to be the best trade of between transform performance and computational complexity in conventional DCT based compression schemes such as JPEG. Therefore, in our scheme, basic transform matrices with a size of $2 \times 2 - 8 \times 8$are computed first. Second, we design a multi lifting scheme for pre filter and DCT matrices obtained from the first step. To do this, we use the matrix factorization method to factorize basic matrices into TERMs. Suppose that matrix L is a lower TERM factorized from basic transform matrix with a size of 3×3. Then, its multi lifting scheme can be obtained.

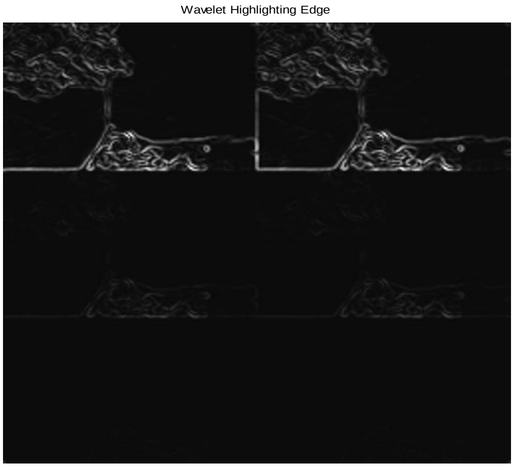


Fig.6**:** ROI segmentation using SARLT

Region merging, region splitting and a combination of region merging and splitting are well known region detection techniques. In characteristic feature thresholding or clustering, threshold level schemes are based on grey level histogram and local properties. Edge detection is the simple and basic technique used in segmentation of images. It is a useful segmentation method used for simple image.

IV. Conclusion

In the method, a shape adaptive reversible integer lapped transform (SA-RLT) method for compression of 2-D remote sensing images is proposed. Based on SA-RLT and object based set partitioned embedded block coder, a new region of interest (ROI) compression scheme is designed for 2-D remote sensing images. Experimental results demonstrate that the proposed transform (SA-RLT) performs better than other existing SA transforms such as shape adaptive discrete cosine transform (SA-DCT), shape adaptive discrete wavelet transform (SA-DWT). A new segmentation method for segmenting the region of interest (ROI) based on colour intensity is proposed here. The new proposed method overcomes the limitations of hand segmentation such as complexity and time to a large extent. The proposed algorithm can effectively improve the overall quality and details of the satellite images since the compression technique used here is lossless. . The delimitations of the proposed model were also analyzed clearly and the simulation tool is selected to perform comprehensive simulations.

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