An Efficient Parallel Processing Approach for Video Surveillance through Satellite

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ABSTRACT
Parallel computation has become a recent trend in research from past few years. Parallel Computation is widely used in weather prediction, earthquake prediction, nanotechnology, astronomy for the study of planetary movements, pharmaceutics, defense for weapon simulation and so on. Satellite plays a major role in military for communication and surveillance. Area surveillance is one of the major application of satellite used in defense. Even though the technology enhancement occurs day by day, nabbing the terrorist activities and illegal border crossing into the nation has become a major primary issue. In this paper, a novel parallel processing approach for border surveillance in monitoring the borders of land and marine of a nation using single satellite is presented. A video dehazing algorithm is considered for parallel processing using OpenMP, a shared memory programming. Independent tasks are assigned to multiple threads of a core exhibiting data and task parallelism. Thus proposed idea of parallel video dehazing resulted in increase in speedup compared to sequential execution time.

Keywords
Parallel Computation; Border; Satellite; Monitor; Video Dehazing; OpenMP

1. INTRODUCTION
Distributed computing has become recent trend in computer applications for running the advanced scientific application programs efficiently and quickly by distributing the task among the different cores or processors. Distributed computing plays a major role in various fields such as weather forecasting, Life science, Predicting the natural hazards, weapon simulation, remote sensing, image processing and so forth. One of the major application is mainly focused on the defense applications such as weapon simulation, automatic target detection and automatic detection of unnatural human behavior at the airports and so forth. Parallel processing is the use of processors or multiple computers to reduce the time needed to solve complex scientific problems, so that the larger problems are divided into smaller ones, distributed among the multiple processors, solved concurrently and the results are congregated to get the desired result. A parallel processing system denotes a multiprocessor computer system comprising of centralized multi-computers or multiprocessors. A Parallel processing system shares a global memory that have an access to all processors supporting communication and synchronization among the processors and hence is known as centralized multiprocessor system. This system can be extended to super computers or massive parallel processing (MPP) computers, if many processors are integrated and each processor is provided with an individual memory connected with other processors by a bus. This kind of computer offers very high performance but requires a special operation system and incurs heavy construction costs in general. Alternatively, a set of computers can be constructed as a parallel processing system, in other words a cluster system, if they are interconnected by a network. Recently, as microprocessors have become greatly enhanced and the needs for parallel computation have increased, relatively cheaper PC clusters have come available and have proved to be popular in general purposes [1] Computers in a PC cluster are little different from ordinary personal computers or workstations, and the processor in each computer can interact with others by a message passing protocol such as MPI (Message Passing Interface) [2] or PVM (Parallel Virtual Machine) [3], through either an Ethernet or other higher speed inter-connections. A general PC cluster consists of a master node, several slave nodes and network devices. A master node takes the role of the user interface, data input/output/distribution and control of slave nodes, and the slave nodes are responsible for data processing. This paper presents a view on the usage of parallel computation for border surveillance both for land and marine through a single satellite for an automatic detection of illegal border crossing.

This paper is organized as section 2 depicts the Literature survey, section 3 presents the state of art of proposed satellite surveillance system exploiting the usage of parallel processing for visual surveillance considering video dehazing as a case study in section 4. Section 5 illustrates an experimental results of parallel video dehazing followed by Conclusion with Future Enhancement.

2. EXISTING SYSTEM
Advancement in space technology has been rapidly increasing in recent year. Satellite plays a major role for the developing and the developed nations for societal needs. Earth Observation, weather prediction, for communication and navigation are some of the applications of satellite. One of the major application of satellite is its usage in military for communication purpose and for earth observation for detection of exact location of enemy troops at the border. Surveillance satellites are broadly divided into two classes [4] area surveillance satellite and close look satellites. Area surveillance satellite maps the entire territory of the nation but cannot identify the objects carefully. Close look satellites facilitate the detailed surveillance of the area connected. Several other measures of surveillance ranging from air dropped sonars to electronic battle fields have been applied by the United States. [5] describes the role of satellite in securing the border. Earth observation satellites provide the detailed images of particular spots where the border crossing peaks. Some of the sensors defends the invisibility that are able to penetrate cloud cover, identify the objects inside the building and detect chemical traces. Spacecrafts such as Cartosat and RISAT are used in India to capture the high-resolution video

of nation's disputed borders as well as still images. South Africa has used satellite imagery to track activity at border control posts between that nation and Zimbabwe. Video and voice communications, data for aircrafts, helicopters, maritime vessels and ground vehicles on border patrol are provided by the satellites which makes to share the images and information for widely scattered forces to operate a single unit. [6] focused on a wireless sensor network (WSN) based system for country border surveillance and target tracking. Border Cooperative and Predictive Tracking Protocol(BCTP) capable of energy-aware surveillance, continuous tracking of objects and individuals crossing a country border and anticipating target motion within a thick strip along the border and estimating the target exit zone and time. Their approach highlights the two objectives to achieve the efficiency of WSN-based surveillance systems such as WSN build on deployment scheme monitoring the total coverage area so that target entering the area is detected and tracking the moving objects in an area of interest. These two objectives ensure energy conservation and continuous monitoring for an efficient tracking. [7] Presented a framework for real-time monitoring of border areas with frequent and active illegal immigration and smuggling. Their approach utilizes Unmanned Aerial vehicle (UAV) or Light Aircraft (LA) for repeat imaging over the short time periods of minutes to hours depending on the border response zone might be rural, urban and remote. Many types of cameras [8] are used in satellite such as the strip cameras, panchromatic camera, panoramic and multi lens camera. Strip Cameras which record images used in missions, requiring object height determination used on an aircraft based platform. The panchromatic cameras also called single lens camera used in satellite imagery applications. The main characteristic of this camera is it senses radiation beyond the visible wavelength (infrared) hence therefore used in photogrammetric purposes for remote sensing applications. Panoramic cameras has a lens having a wide Field of View hence enabling to take the photograph of a large area typically of 40 to 50 km in length and breadth but cannot be used for photogrammetry, as introduces distortion hence useful for preliminary surveys. Multi-lens camera has 4 lenses each of which focuses light on Red, Blue, Green and Infrared filter respectively, thus useful to take photographs of exactly the same area on the ground in four different bands. To the best of our knowledge an unsleeping satellite surveillance for monitoring the border both land and marine using single sensor has not been reported in the literature.

Disadvantages

1. Separate sensors or satellites to monitor land and marine.
2. Limited coverage on a region using camera.
3. Many cameras and sensors are needed for a coverage which focuses on specific region.

3. STATE OF ART

India covers a total area of 1,269,219 square miles (3,287,263 square kms) [9]. India measures 1,822 mi (2,933 km) from east to west and 1,997 mi (3,214 km) from north to south. It has land frontier of 9,445 mi (15,200 km) and a coastline of 4,671 mi (7,516.6 km). India is surrounded by neighboring countries. The costal boundaries that share with other countries is 7516 km and land boundaries is 15106.7 km.[10] Land area shared by India is 3488km with china, 3323km with Pakistan,4096km with Bangladesh, 1643 km with Myanmar, 699 km with Bhutan and 106km with Afghanistan respectively. Infiltrations destabilize the growth of India which occur along the border. Infiltrations of different types such as migrants, terrorists, drug traffickers, animal poaching and smuggling, intrusions along the border and land intrusions. More than 2000 human intrusions into India are recorder and is increasing every year.

Reconnaissance satellite [11] are generally ones that observe the earth from space and by zooming can view anything and everything on earth's surface. These system are mainly helpful for military operations which allow for eavesdropping visually, high resolution viewing and recognition. This system can be used for tracking anything, anyone at any time especially for monitoring at the borders. Since Parallel Computation has becoming an emerging technology, it can be used for surveillance at the border using a satellite. The design of sensors or payloads in satellite, used for monitoring the land, marine and underground surfaces of some feet. The sensors in satellite must be of high resolution of low earth orbit, multispectral imaging is needed which provides coverage at night that captures videos of borders and this data are transmitted to the base station. Data received is to be preprocessed independently for intrusion detection and also for the detection of illegal activities. The geographic area of India is radially partitioned into 8 sectors as depicted in figure 1 for this purpose. Each partitions are processed independently and parallel at a time by different processors. A Virtual line is created at the border. The real time video is captured at the satellite, sent to the base station and stored in database. If an intruder crosses a pre-defined virtual line, the sensor in the satellite must automatically detect the event and can trigger alarms to respective troops at the border via the base station as illustrated in figure 2.

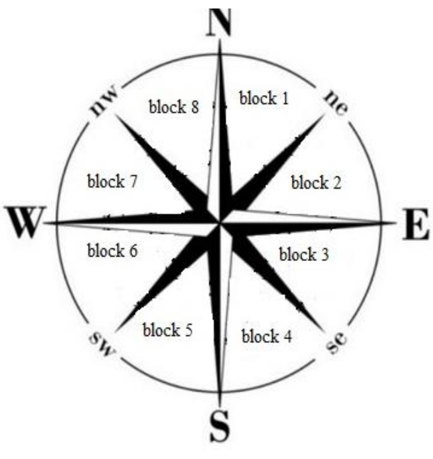


Fig. 1.Radial partition

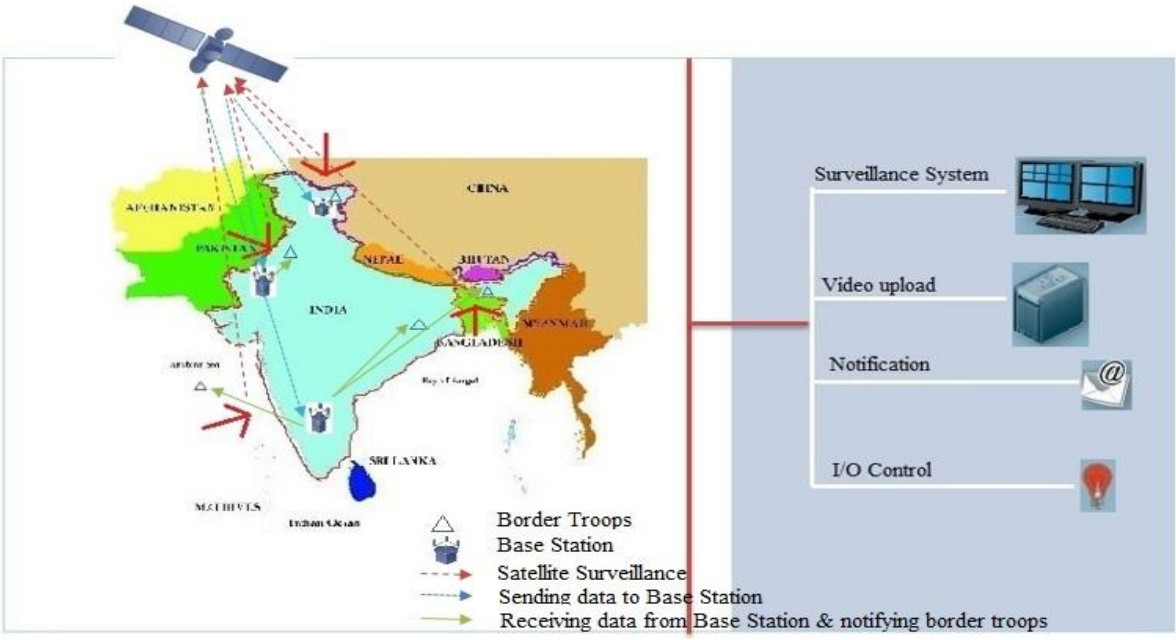


Fig. 2. Satellite Surveillance System Architecture

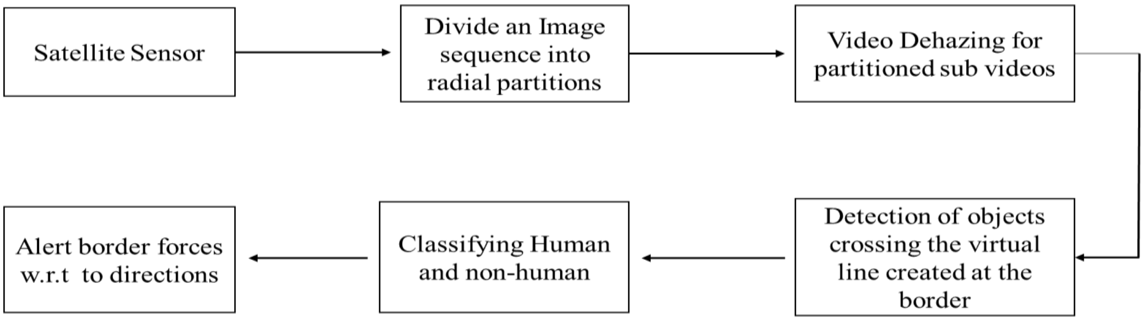


Fig. 3. Block Diagram of the proposed system

The proposed system comprises of 4 modules video enhancement, detecting the object crossing the virtual line created at the border, object classification and alert the border troop's w.r.t to directions. Video enhancement is the preprocessing step in image processing. Bad weather condition such as haze, fog, dust snow, rain, smoke and mist degrade the quality of an outdoor images. It is an exasperating as it reduces the contrast of a video. Poor weather conditions diminishes the visibility of scenes and is threat to reliability of applications such as border security, video surveillance and so forth. Hence video dehazing is considered for parallel computation.

Advantages

1. Single Satellite/Sensor monitoring both land and marine.
2. Helpful for monitoring the borders of unreachable places such as siachen glaciers, dense forest region and so forth.

Disadvantages

1. It's a brainstorming work of designing the single sensor for monitoring both land and marine and monitoring at a time.
2. Development of single sensor in the satellite might be expensive.

3.1 Video Dehaze

Atmospheric scattering model [15] is widely used in video and image dehazing. It is based on mathematical model.

$$I(x) = J(x)t(x) + A(1 - t(x)) \quad (1)$$

I is hazy image, A is 3-dimensional RGB vector i.e, atmospheric light, J is scene radiance and x is a 2 dimensional coordinate of the pixel within the image and t is the thickness of the hazes called transmission map. Restoring J given I is the target of dehazing. J(x)*t(x) is called the direct attenuation. A*(1-t(x)) called airlight. The estimation of atmospheric light A and transmission t is the key step which affects the restoration of foggy image. The proposed block diagram of parallel processing of video dehazing is illustrated in figure 4.

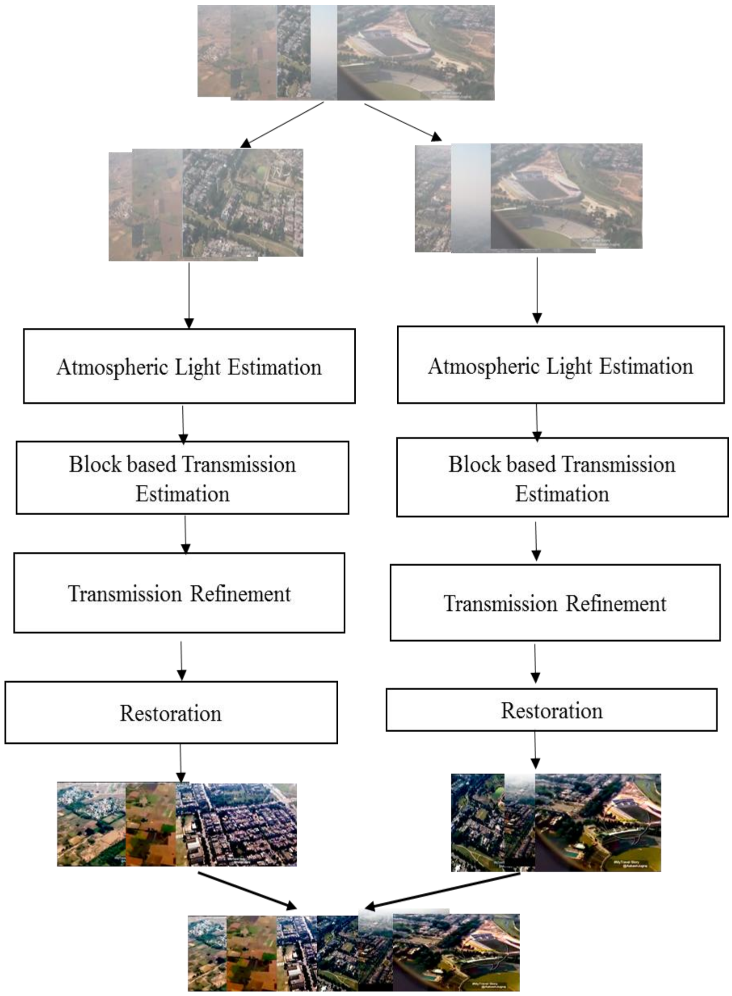


Fig. 4. Block diagram of Parallel Video Dehazing

Parallel Processing is highly amenable for processing videos. High degrees of locality in time is exhibited by video. What the processing done on the 5^{th} frame is independent of processing done for 400^{th} frame of a video sequence. This locality makes it possible for the division of video into sub-videos and process independently. Task and Data parallelism is exhibited for processing the sub-videos. It is the form of a parallelization techniques. A non-iterative work-sharing construct that accomplishes task parallelism that contains a set of structured blocks that are to be divided among and executed by the threads in a team.

Video Dehazing is decomposed into three components such as atmospheric light estimator, transmission estimation and refinement.

3.1.1 *Atmospheric Light Estimator*

This component is used to estimate the A in Eqn (1). [16] uses hierarchical searching based method on the quad-tree subdivision. Initially image is divide into four rectangular regions, score of each region is defined as subtraction of average pixel value and the standard deviation of the pixel values within region. Then the region with highest score is selected and further divided into 4 smaller sub-regions. The process is repeated until the size of the selected region is smaller than a pre-specified threshold.

3.1.2 *Transmission estimation*

This component is used to estimate J in Eqn (1). Eqn (1) can be rewritten as

$$J(P) = \frac{1}{t(I(p) - A) + A} \qquad (2)$$

J(p) is the restored scene radiance depending on the selection of the transmission t. As the estimated t gets lower the contrast of a restored block increases. Contrast measure is inversely proportional to the transmission t, to increase the contrast of restored block small value of t is considered. By doing so information loss is exhibited. Contrast and the information loss cost are designed and then minimize the two cost functions. Mean Squared Error (MSE) contrast is employed to enhance the de-contrast image. It represents pixel values variance [17] given by

$$C_{MSE} = \sum_{p=1}^{n} \frac{(Jc(p) - aJ)^2}{N} \qquad (3)$$

Where N is the number of pixels in block from Eqn (2), C ϵ (r,g,b) is the color channel index, aJ is the average of Jc. Contrast cost is defined by taking the negative sum of the MSE contrasts for three color channels of each block as

$$E_{contrast} = -\sum_{c\in(r,g,b)}\sum_{P\in B}\frac{(Jc(P)-aJ)^2}{N_B} = -\sum_{c\in(r,g,b)}\sum_{P\in B}\frac{(Ic(P)-aI)^2}{t^2 N_B} \quad (4)$$

Where N_B is the number of pixels and aJ,aI are the average values of $J_c(p)$ and $I_c(p)$ in B Information loss cost for block can be maximized as squared sum of truncated value as

$$E_{loss} = \sum_{c\in(r,g,b)}\sum_{P\in B}\left\{\min\{0, Jc(P)\})^2 + (\max\{0, Jc(P)-255\})^2\right\} \quad (5)$$

terms (min{0,J_c (p)})and max{0,J_c(p)-255} denote truncated values due to the underflow and the overflow, respectively Hence this algorithm can strike a balance between contrast enhancement and the information loss.

3.1.3 Transmission Refinement

This element enhances the image details. Block based transmission map is refined by using an edge preserving filter called guided filter, alleviating the blocking artifacts. Guided filter is adopted [18] that the filtered transmission t(q) is an affine combination of the guidance image I(q) as follows.

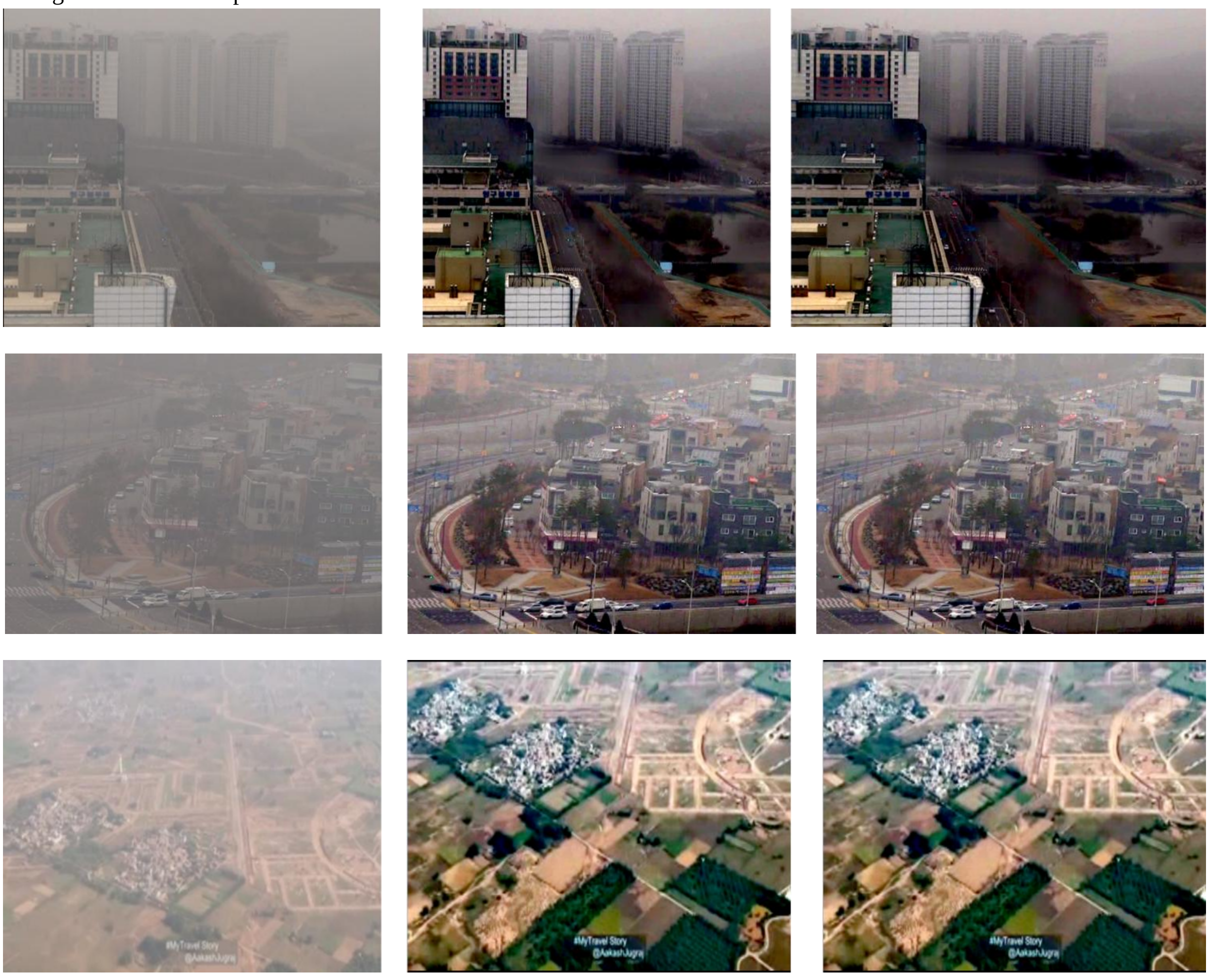
$$at(q) = s^T I(q) + \Psi \quad (6)$$

where Ψ is an offset and $s=(s_r,s_g,s_b)^T$ is a scaling factor. The offset and the scaling vector are determined for each local window of size 41x41. The window slides over an image pixel by pixel. A shiftable windows is used for each pixel within a search range and optimal shift position is selected minimizing the variance of pixel values within the window. The transmission values of the optimal window is refined via Eqn (6). Transmission value of each pixel is determined as an average of all associated refined values. The unreliable transmission values derived from the edge regions is reduced by the shiftable window scheme by alleviating blurring artifacts. An input frame is dehazed after obtaining the pixel based transmission map based on Eqn (1). Minimum transmission value is constrained to be greater than 0.1 as smaller value tends to amplify noise. Speed is improved for refinement techniques by using parallel programming tools OpenMP [19] and SIMD [20]. OpenMP is applied to restore the values of pixels using four processor cores in parallel and SIMD is used in the transmission refinement step by performing the computation for four pixels in parallel.

4. PERFORMANCE EVALUATION

The experimental results of proposed parallel processing of video dehazing algorithm exhibiting the task parallelism and data parallelism are presented with the performance.

The testing of parallel processing approach of video dehazing is done on hardware Intel® Xeon® CPU E3-1220@3.10 GHz of 8.00GB RAM. Microsoft Visual Studio 2010 environment is used for implementation by considering three video files of .avi and .mp4 format. Cross.avi of size 5.97 MB with 640x480 resolution, riverside.avi of size 2.25MB with 640x480 resolution and view_mohali.avi of size 47.0MB with 320x180 resolution. For experimentation, 400 frames comprising of three bands RGB is considered for experimentation.



(a) (b) (c)

Figure. 5.(a) input frame, (b) output of serial video dehaze and (c) output of proposed parallel video dehaze

Table 1 Comparison results for 400 frames

Filename	Size	Resolution	Serial Time	Parallel Time	Speed Up	Efficiency
riverside	2.25MB	640x480	24.96	15.46	1.6137	0.8068
View_Mohali	47.0MB	320x180	7.682	3.46	2.2144	1.1072

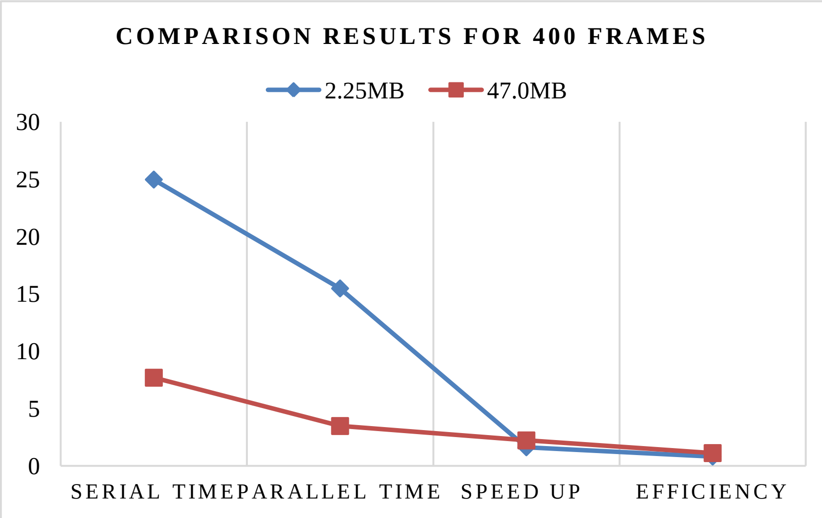


Fig 6. Comparison results for 400 frames

The Table 1 depicts the comparison results of serial and parallel execution time for 400 frames, followed by its graphical representation in Figure 5. For the video file of size 47.0MB 3622 frames are considered for testing.

Table 2. Comparison results of 3622 frames

Filename	Size	Resolution	Serial	Parallel	Speed Up	Efficiency
View_Mohali_Stadiums	47.0MB	320x180	178.289	86.89	2.0518932	1.025946599

Table 2 illustrates the comparison results of serial and parallel for 3622 frames. From the experimental results, it is estimated that parallel execution time is less compared to serial execution. It is estimated form the experimentation the efficiency is dependent on the number of processes. As the number of usage of processes increases efficiency decreases speedup increases.

5. CONCLUSION

A proposed parallel processing methodology for border surveillance in monitoring both land and marine using single satellite is presented. A parallel video dehazing, a preprocessing step in image processing is presented using shared memory programming openMP. Data and Task parallelism both are exhibited in video dehazing, where independent tasks are assigned to multiple threads of a core. An experiment is performed on standalone systems, resulting in performance enhancement compared to sequential execution time.

Designing a single sensor for monitoring the borders of land and marine of a nation and sensing beneath land & water surface of some feet using single satellite parallel is a challenging task. A classification of human and non-human through a satellite need to be enhanced in future. Satellites are the only technology, which provides an insomnious vigilance from thousand kilometers for monitoring the borders of a nation.

6. REFERENCES

[1] Quinn, M.J, Introduction to Parallel Processing: Theory & Practice, McGraw Hill Inc. 2nd Edition 1994.

[2] Message Passing Interface Forum. MPI: A message-passing interface standard. International Journal of Supercomputer Applications and High Performance Computing 1994; 6(3-4):159–416.

[3] netlib.org/pvm3/book/pvm-book.html

[4] Raimo Väyrynen, Military uses of Satellite communication, Instant Research on Peace and violence, Tampere Peace Research Institute, University of Tampere, Vol. 3, No. 1(1973), pp. 44-49.

[5] How Satellites make a better world, Society of software professionals International, pp.1-28.

[6] Noureddine Boudriga, A WSN-Based System for Country Border Surveillance and Target Tracking, Advances in Remote Sensing, 2016,5, 51-72. Doi: 10.4236/ars.2016.51005.

[7] Lloyd L. Coulter, Christopher D. Lippitt, Douglas A Stow and Richard W. McVeigh, Near Real-Time change

detection for border monitoring, ASPRS 2011 Annual Conference Milwaukee, Wisconsin May 1-5, 2011.

[8] www.angelfire.com/co/pallav/celmechanics.html

[9] http://statisticstimes.com/geography/area-of-indian-states.php

[10] Puspitha Das, India's Border Management, Institute of Defense Studies and Analyses, New-Delhi, India 2010.

[11] Robert Shimonski John Zenir, Esq,Allison Bishop, Cyber Reconnaissance, Surveillance and Defense, Elsevier SynGress, 2015.

[12] Computers and Defense Applications, 2nd Edition, popular science and technology series, Defence Scientific Information and Documentation Centre, Defence Research and Development Organization, Ministry of Defence, Delhi 1991.

[13] Subramanian A L, Multi-Procesor, multi-board real time software architecture for Defense Applications, Mistral Solutions pvt. ltd, 2012.

[14] Patrick Korody, "Satellite Surveillance within US Borders", Ohio State law Journal, Volume 65, 1627-1663, 2004.

[15] Zhuwen Li,Ping Tan, Robby T.Tan, Danping Zou, Steven Zhiying Zhou and Loong-Fah Cheong, Simultaneous video defogging and stereo reconstruction, In IEEE Conference on Computer Vision and Pattern Recognition(CVPR), 2015, pp. 4988-4997.

[16] Jin-Hwan Kim,Won-Dong Jang, Jae-Young Sim, Chang-Su Kim, Optimized contrast enhancement for real-time image and video dehazing, Elsevier J. Vis. Commun, Image R. 24 (2013) pp.410-425.

[17] Eli Peli, Contrast in complex images, J. Opt. Soc. Am. A Vol.7, No.10 ,1990, pp.2032–2040.

[18] Kaiming He,Jian Sun, Xiaoou Tang, Guided image filtering, In: Proc. IEEE Transactions on pattern analysis and machine intelligence,Vol. 35,2013, pp. 1-14

[19] OpenMP Architecture Review Board. OpenMP specifications. [June 2008].

[20] D. Patterson, J. Hennessy, Computer Organization and Design: The Hardware/Software Interface, fourth ed., The Morgan Kaufmann Series in Computer Architecture and Design, Elsevier Morgan Kaufmann, 2009.