Video Surveillance Through Distributed processing

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Abstract— **This paper is an attempt to create a distributed environment for low end video surveillance. The performance of the system under various conditions like input size, number of computers used and complexity of processing algorithms will be discussed. To optimize performance various transmission delays were reduced and a trade off graph between the number of system used and the window size of video file was plotted. This project will help in studying the characteristics that influence the performance of a distributed system and also build a robust environment for real time video signal processing.**

Keywords— **Distributed Architecture, Distributed systems, Video Processing, Background Subtraction, Surveillance system.**

I. INTRODUCTION

Distributed computing technology has been used for decades to help process large computational problems by allowing multiple computers to work on the problem simultaneously. With the advent of the Internet, distributed computing has reached a new level. Distributed computing projects using user-donated processing time have become increasingly popular due to speed and effectiveness. In this paper we present a generic and flexible approach for an intelligent real-time video surveillance system along with integrated video surveillance tool which fetches any unusual or interesting event. We implemented background subtraction method to merely identify moving and mistrusted objects from the portion of a video frame that is different from the background frame.

The paper surveys few applications of distributed computing environment along with the techniques for frame differencing and adaptive filtering [1] for detecting suspicious objects in a video sequence.

The primary aim of this paper work is therefore to present a theoretical description of the problem of video processing and then to establish a method to attack the given problem in real time using a distributed architecture.

A. Distributed System

Distributed computing environment has always been a part of computation and not far from reality since its inception. A distributed System is a collection of data that logically belongs to the same system but is spread over the computer network. The nodes of the distributed system can have the same network address and may be in the same room. With the rapid and hasty development in the fields of internet, wireless network etc. Analysing and mining distributed data sources are much in need of data mining algorithms to design distributed and parallel applications [2,3,4]. Orthodox data mining algorithms often make the assumptions that the data is centralized, resident and static. Today this assumption is no longer feasible .As plethora of huge amount of data are raised and stored in the database every day. In these conditions, centralized data mining algorithm must waste lots of I/O resources, and excessive communication overhead to transmit the abundant amount of data. Also the current requirement of data mining is not just limited to data ware house. For achieving real time results, we are progressing towards mining stream data.

B. Video processing

Number of cameras being used for scene analysis is growing largely [5]. Many of these are applied for surveillance and monitoring because of the low cost and method for data collection. Automatic detection of the errant conditions in video surveillance data is a challenging problem in computer vision for the analysis and the security [6]. Video cameras are quite cheap and inexpensive tools to be used in a huge number but, manually reviewing the large amount of data generated is often tedious .Thus, algorithms that require trivial or no human input are an attractive solution. In general the system developed specifically for surveillance should be able to process static video as well as streaming video. This prompts us to use a distributed and parallel architecture for processing.

C. Problem statement

- To implement a distributed processing tool for online/offline video processing.
- To implement video surveillance for mere event detection, using background subtraction method.
- To study the tradeoff in processing time and I/O delays during distributed video processing.

II. SURVEY AND REVIEW

For the distributed systems implementation we have several architecture choices. Many of the distributed architectures are centralized like mainframe systems and dumb terminals. In such architecture all of the computation is done on the mainframe. Each line or keystroke is sent from the terminal to the mainframe. Here only systems are geographically distributed. But the processing is concentrated on the server entirely; therefore, this type of system is not ideal for distributed development. A little more distributed approach is that of client and server architecture. The clients are work stations or computers which perform computations and formatting of the data. However, the data and the application on which they perform reside on the server. A more decentralized approach is achieved by implementing Distributed-with-Coordinator architecture which we will be using for video processing capabilities.

Background subtraction involves identifying and removing foreground objects from the background in a video frame sequence. There are many methods to implement background subtraction but many of them are not viable enough for practical applications. Each of these methods has some advantages and disadvantages of their own.

These methods are of different complexities.

- Low-complexity: The temporal frame difference method, temporal median/mean method.
- Medium complexity: The approximate median method.
- High-complexity: Ex: The Mixture of Gaussians method.

1) Frame Difference:

It is the simplest method for implementing background subtraction. The difference between two consecutive frames is calculated and if the difference in pixel value is greater than the threshold value set for that pixel, it is considered as the foreground.

For frames with uniformly distributed intensity values, some pixels which are in interior can be considered as part of the background. For objects which are not continuously moving, i.e., if the frame has not changed, it becomes part of the background. The threshold value has to be found empirically, which is difficult to calculate.

This method has mediocre computational requirements. It is highly adaptive since the background is defined by the previous frame. It subtracts out noise from the background better than other methods.

2) Temporal Median:

This is one of the most extensively used background subtraction technique. The background estimate is calculated as the median of each pixel location of all the frames assuming that the pixel stays in the background for more than half of the frames in the buffer. A temporal median filter takes some fixed no of frames of a video and, for each pixel, finds the median for all of these values [17]. This median value becomes the background for the next frames.

Giving a better and sharper background this method fails to fulfil the timing constraints.

3) Temporal Mean:

This method is similar to temporal median method explained above except that instead of finding median ,i.e., the middle value , we use mean which is the average of the all the frames. Noise is higher in this method than temporal median and hence it is more difficult to validate the background.

4) Approximate median:

Median filtering has proved to be robust and has very high performance for a medium complexity method but it requires a large amount of memory for storing and processing of many frames. A probable solution to this problem is storing less number of frames at the cost of slower adapting background. To overcome these problems, UK researchers N.J.B. McFarlane and C.P. Schofield devised the method of approximate median [18] explained below. If a pixel in a frame has a value larger than the corresponding background pixel, the background pixel is incremented by one. Similarly, if the value is less than the background pixel, the background pixel is decreased by one. Therefore, eventually half the input pixels are greater than the background, and half are less than the background approximately the median.

This method is more useful for extracting the object from the background since by more slowly adapting background includes a more detailed frame. This result obtained is similar to the temporal median method. This method is good trade-off between performance and cost as it provides the performance of temporal median method and costs not much more than frame differencing method.

A comparative study of each of the above methods is summarized in the Table I [19].

TABLE I : ACCURACY AND AVERAGE PROCESSING TIME

S No	**Method**	**Accuracy**	**Average Processing Time (frame/second)**
1	Temporal Median	86.14	1.8570
2	Temporal Mean	80.55	1.5130
3	Frame Differencing	99.00	0.0120
4	Approximate Median	91.96	0.0490

Challenges involved in developing a good background algorithm are. First, it must be robust versus changes in illumination. Second, the model should react quickly with respect to the changes in the background. In response to the foreground segmentation algorithm that combines image analysis with a reference background image for this many different approaches have been proposed for the generation of the background model but if the dynamics of the scene are too complex standard techniques would suffer from significant errors.

III. SYSTEM DESIGN

The project work is divided in to two modules. First is the development of robust distributed client server architecture and second is a module implementing video processing which is expandable for newer algorithms and features. The basic set up of such a distributed environment has been created and the expansion of other possible features is left for future work [13].

A. Distributed Architecture

A distributed system is one in which components located on network computers communicate and coordinate their actions only by passing messages. The sharing of resources is the main motivation for constructing distributed systems. Resources may be managed by servers and accessed by clients or they may be encapsulated as objects and accessed by other client objects.

In **Distributed-with-Coordinator** design [7,8], the nodes or sites depend on a coordinator node with extra knowledge or processing abilities. Or Coordinator might be used only in case of failures or other problems. However the distributed operating system services are known to the server terminals. It is just the question of choosing who the coordinator among all the systems is. This coordinator could be chosen manually or through election. Coordinating here means distributing data to terminals, decision making in case of failure, choosing the priority of the terminals and security aspects. As shown in Fig.1

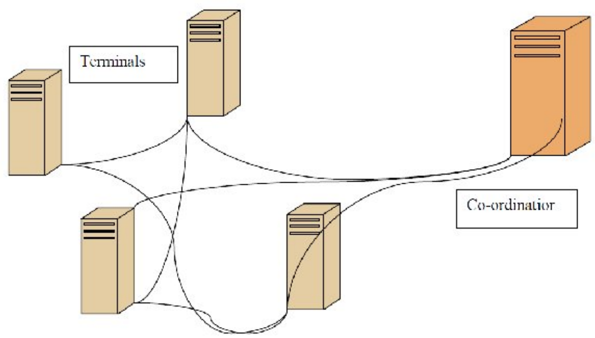

Fig.1 Distributed Architecture with Coordinator

The architecture used here is not completely decentralized one. It has been classified as architecture consisting of a coordinator [9]. The coordinator here is acting as a client who contains all the information about the servers and the work distributed to them.

Options have been given to select the size of window to be passed to each server for processing. Also option was given to choose the number of servers to execute the program. This will enable us to study the maximum number of servers sufficient to get the best possible processing time for a given data length. It is to be noted that the best possible processing time for any data length is not proportional to the number of servers, since the I/O constraints, transmission delays and time to allocate and de-allocate memory affect the processing time. In order to achieve good performance care should be taken such that these delays don't exceed the actual processing time. The scalability concept i.e. expandability of the system is taken care similarly [10]. We can keep any number of servers active to accept the requests coming from the coordinator.

B. Background Subtraction Method:

In general, system developed for these areas must integrate amongst other tasks like analysis of their static environment and detection of static/moving objects [9] surrounding their space of interest.

1) Architectural Specification:

System mainly consists of Pipe and Filter architectural style. Output of one module is the apparent input another. This style shows the flow of data in the architecture for change detection using background subtraction. It uses temporal median/mean for frame differencing Fig 2.

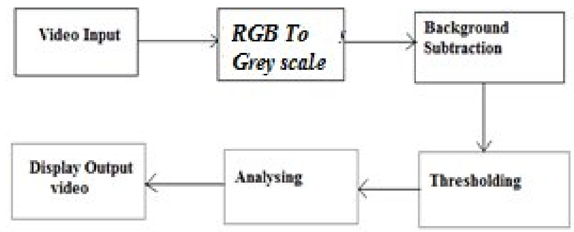

Fig-2 Architecture for Tracking using Background Subtraction

This paper presents video surveillance system implementation using Background Subtraction [11]. The process of separating the foreground objects from the background in a continuous sequence of video frames. Background subtraction involves subtraction between two consecutive frames. The value is calculated and if it comes out to be greater than the threshold value it is considered to be foreground.Fig.3. These events are notified and sent over the network for further analysis.A Threshold algorithm is defined by the system to determine unusual changes. These changes are calculated using consecutive frame comparison of the video sequence[14].

Thus the foreground image is input to an automatic threshold algorithm.

If FGxy > threshold
FGxy = 1
Else
FGxy = 0

2) Frame differencing:

The current frame is simply subtracted from the previous frame, and if the difference in pixel values for a given pixel is greater than a threshold Ts [15], the pixel is considered part of the foreground.

$$| FRAME(i) - FRAME(i-1)| > Ts$$

Fig.3 Foreground Extraction

All the frames where there is a significant change are forwarded to the distributed network for processing and analysis. The remaining data where there is no change in the background are stored in back end storage. This helps the entire surveillance system to be fast and process only the needed frames without going through the whole video sequence.

C. System Components Description

The various modules of the software part of the system are explained hereunder.

1) Camera Network:

Closed Circuit camera used in network [6] which are used in the system architecture. Capable for streaming video without any delay. There by subject in supplying the video stream t o the coordinator system for the implementation process.

2) Network:

Working in a distributed system implies to have an efficient use of the bandwidth. Each video source has an associated multicast channel. This multicast channel is accessed through a UDP connection by the coordinator system connected in local area network.

3) Nodes:

Mainly Nodes are the computer which specific operations to perform. With the improvement in the field of mobile computing mobile processing devices [16] can also be used nodes for the distributed system.

IV. RESULTS

The system has been tested using image processing tool box on periodic video frames, with several nodes committed to the distributed system. Graphs have been constructed to compare the theoretical and obtained values. First a video file of is taken, on which video processing has been done. The signal is windowed in to sizes ranging from 128 to 4096, incrementing by multiples of 2. The following are the practical processing times obtained by the respective windowed sizes.

TABLE II : PROCESSING TIME OF VIDEO SIGNAL

Window size	**Processing time in mille seconds**
128	280
256	300
512	328
1024	390
2048	530
4096	625

Then the data is distributed and retrieved among several nodes ranging from 1 to 6 and the processing time is obtained. The video frame size for each node has been varied so as to obtain processing speed as that of video capture. In case of static video processing, some fixed frame size could be chosen to achieve any acceptable processing speed.

TABLE III : PROCESSING TIME USING MULTIPLE NODES

Number of Nodes	**Processing Time in mille Seconds**
1	31100
2	17090
3	11200
4	12875
5	14250
6	12422

The above value is calculated by taking the average of 5 executions. Results may vary from system to system and the available free main memory on the system. We can observe that there is linearity in performance up to 3 servers. But as number of system increases vary very critical because of the external factors affecting the processing of the individual system. The factors affecting are the I/O processing, waiting for multiple clients and accessing multiple nodes. Thus in increasing the number of nodes has no significant decrease in processing speed. On the contrary, after a certain point, increase in number of nodes diminishes the performance. This results in anomalies of processing times as shown in Fig 3. It was observed that performance was optimum at 3 nodes.

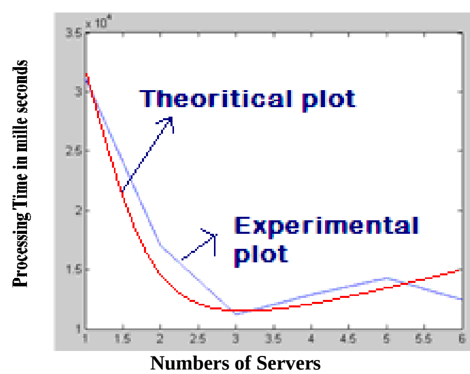

Fig 3. Performing graph of Distributed System

V. CONCLUSION

As discussed before, one of the purposes of this project was to bring forth the concepts involved in Distributed systems and their scope in Real time video Surveillance. While implementing these concepts, we observed the tradeoff between the numbers of systems used, i.e. higher costs and faster processing. We strived to find a balance between cost factor and the speed factor by equating theoretical and experimental values.

The practical importance of the system can be seen when performing online video processing. In this case the data is read in to windows of some fixed size and distributed to all the servers in the order of availability. The basic infrastructure can be used to build distributed systems for other kinds of signal processing tasks like audio processing etc.

This naïve design of distributed real time video processing can be used in Banks etc during night hours. The system detects any change in foreground as captured by CCTV cameras and signals an alarm to monitoring base station. When the number of sensors are quite large and events are minimal, human need to continuously monitor such laborious tasks can be removed.

VI. REFERENCES

[1] Szolgay, D.,Benois-Pineau, J.,Megret, R.,Gaestel, Y.,Dartigues, J. F.,"Detection of moving foreground objects in videos with strong camera motion", Pattern Analysis and Applications, volume 14. issue 3, august 2011.pg 311-328.

[2] Sumathi, R., Kirubakaran, E., "Architectural perspective of parallelizing association rule mining", IEEE-International Conference on Advances in Engineering, Science and Management, ICAESM-2012, Article number6215884, Pages 437-442.

[3] Cao, W., Hu, X., Dong, C., "Research of the mining algorithm based on distributed database ", Proceedings - 2011 8th International Conference on Fuzzy Systems and Knowledge Discovery, FSKD 2011, Volume 2, 2011, Article number6019664, Pages 1252-1256

[4] Sridhar, S.,"Distributed data mining system for renal data analysis to improve the performance of expert system", European Journal of Scientific Research, Volume 63, Issue 4, November 2011, Pages 498-502.

[5] Dittrich, F., Koerich, A.L., Oliveira, L.E.S., "People counting in crowded scenes using multiple cameras",2012 ,19th International Conference on Systems, Signals and Image Processing, IWSSIP 2012 2012, Article number 6208090, Pages 138-141.

[6] Wang, X., "Intelligent multi-camera video surveillance: A review",Pattern Recognition Letters, Volume 34, Issue 1, 1 January 2013, Pages 3-19.

[7] Riakiotakis, I. , Ciorba, F.M. , Andronikos, T. , Papakonstantinou, G., "Distributed dynamic load balancing for pipelined computations on heterogeneous systems", Parallel Computing, Volume 37, Issue 10-11, October 2011, Pages 713-729.

[8] Komenda, J , Masopust, T , Van Schuppen, J.H,"Coordination control of distributed discrete-event systems", Lecture Notes in Control and Information Sciences Volume 433, 2013, Pages 147-167

[9] Debard, G.af, Karsmakers, P, Deschodt, M, Vlaeyen, E, Dejaeger, E, Milisen, K, Goedemé, T, Vanrumste, B, Tuytelaars, T ,"Camera-based fall detection on real world data", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics),Volume 7474 LNCS, 2012, Pages 356-375.

[10] Palmieri, F., "Scalable service discovery in ubiquitous and pervasive computing architectures: A percolation-driven approach", Future Generation Computer Systems, Volume 29, Issue 3, March 2013, Pages 693-703.

[11] Ye, Q , Zhang, Y.,"Moving object detection and tracking algorithm based on background subtraction", Applied Mechanics and Materials, Volume 263-266, Issue PART 1, 2013, Pages 2211-2216.

[12] Subudhi, B.N , Ghosh, S , Ghosh, A , "Change detection for moving object segmentation with robust background construction under Wronskian framework" Machine Vision and Applications, 2013, Pages 1-15.

[13] Tian, Y , Senior, A , Lu, M , "Robust and efficient foreground analysis in complex surveillance videos", Machine Vision and Applications,Volume 23, Issue 5, September 2012, Pages 967-983.

[14] Xiong, W. , Xiang, L., Li, J., Zhao, X., "Moving object detection algorithm based on background subtraction and frame differencing", Proceedings of the 30th Chinese Control Conference, CCC ,2011, Article number6001479, Pages 3273-3276.

[15] Mohamed, S.S. , Tahir, N.M., Adnan, R,"Background modelling and background subtraction performance for object detection", Proceedings - CSPA 2010: 2010 6th International Colloquium on Signal Processing and Its Applications 2010, Article number5545291.

[16] Lim, K.-W, Seo, Y, Jung, W.-S , Ko, Y.-B , Park, S.,"Design and implementation of adaptive WLAN mesh networks for video surveillance", Wireless Networks 2013, Pages 1-14.

[17] Cucchiara, R.,Grana, C., Piccardi, M.,Prati,A.,"Detecting Moving Objects, Ghosts and Shadows in Video Streams", IEEE Transaction on Pattern Analysis and Machine Intelligence, Oct 2003, Vol.25, Issue 10, Pages 1337-1342.

[18] McFarlane,N.J.B,, Schofield,C.P.," Segmentation and tracking of Piglets in Images" , Machine Vision and Application, 1995, Volume 8, Issue 3, pages 187-193.

[19] Naraghi,Nima Seif, "A Comparative Study of Background Estimation Techniques", Eastern Mediterranean University, September 2009, Gazimagusa, North Cyprus.